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ART. XLIII.—*The Quantitative determination of Niobium;* by T. B. OSBORNE.

NIOBIUM occurs in nature almost always in connection with tantalum and titanium, in the presence of which it has been heretofore impossible to obtain more than an approximate determination on account of the close analogy of the behavior of these three elements, when occurring together, toward reagents.

Marignac proposed in 1866 (Arch. de Sc., xxv, p. 17) the process now generally employed for the determination of niobium, but as he says in describing his method, only approximate results can be obtained by its use. His method depends on the difference in solubility of the potassium fluorine salts of tantalum, niobium and titanium. Tantalum forms a salt of the composition $TaF_5 2KF$ dissolving at ordinary temperatures in 150–200 parts of water acidulated with hydrofluoric acid and crystallizing in fine needles. Niobium on the other hand forms a salt of the composition $NbOF_5 2KFH_2O$, dissolving in twelve parts of water and crystallizing in scales isomorphous with the corresponding titanium salt. The potassium titanium fluoride dissolves in ninety-six parts of water.

Marignac adds bifluoride of potassium to the solution of the fluorides of tantalum, niobium and titanium, and concentrates till scales of $TiF_5 2KF$ or $NbOF_5 2KF$ appear. The $TaF_5 2KF$ is filtered and washed with the aid of a pump until the washings no longer give any orange red precipitate with solution of galls after standing two hours. On account of the solubility of the $TaF_5 2KF$ the mother liquor containing the $NbOF_5 2KF$ must always be a saturated solution of $TaF_5 2KF$ and likewise a loss must occur on washing, so that even if the process of

crystallization be several times repeated, as is usually necessary, a very considerable loss must occur. Moreover, the tantalum potassium fluoride cannot be entirely freed from niobium in this way, for I found in preparing $TaF_5 2KF$ that the niobium cannot be entirely removed by simply crystallizing and washing, as I was compelled to recrystallize several times before the $TaF_5 2KF$ gave no evidence of the presence of niobium, when tested by reducing with zinc and hydrochloric acid. Titanium will, when present in any considerable quantity, render the application of this method still more uncertain on account of the intermediate solubility of the potassium titanium fluoride and its close resemblance to the $NbOF_5 2KF$.

From this description it will readily be seen that this method is open to serious objection and can only find acceptance in want of a better. I therefore undertook an investigation of the reduction with zinc in acid solutions containing niobium with the hope of discovering a more accurate and less difficult method of determination. The salts of tantalum and niobium I prepared from columbite from Branchville, Connecticut, in the following way: The mineral was ground to pass a sieve of 100 meshes to the inch, and 500 grams fused with bisulphate of potassium in a platinum dish, 100 grams at a time. When thoroughly fused the mass was immediately poured into cold water which caused the separated tantalic and niobic acids to granulate and expose a large surface to the action of the water, whereby the solution of the bisulphate of potassium was very materially promoted and the lumps broke up easily on stirring, the tantalic and niobic acids separating partly in a flocculent and partly in a granular form.

After washing by decantation the residue was treated with ammonium sulphide and then filtered and washed to remove any tin or tungsten which might be present. Hydrochloric acid was then added and after washing, the residue was obtained free from iron and manganese. The residue was next treated with hydrofluoric and sulphuric acids, in order to remove any silica, precipitated with ammonia and washed free from sulphates. The tantalic and niobic acids thus obtained were dissolved in an excess of hot hydrofluoric acid and carbonate of potassium added gradually, and after cooling, the $TaF_5 2KF$ filtered off. The crude $TaF_5 2KF$ was recrystallized several times and washed till no reduction whatever took place on testing with zinc and hydrochloric acid. The mother liquor from the crude $TaF_5 2KF$ was then nearly neutralized with carbonate of potassium which caused the solution to nearly solidify from the formation of $NbOF_5 2KF$. This product was then recrystallized several times and tested for tantalum by boiling with pure water, when, according to Marignac, if the slightest trace of tantalum were present, it would sep-

arate as an oxyfluoride. None was found. Analyses of the $NbOF_3 2KF H_2O$ thus obtained gave the following results.

			Calculated.
H_2O	5·92	5·90	5·97
Nb_2O_5	36·92	36·84	36·87
K_2	26·07	26·13	25·97
F_5	31·09	31·13	31·19
Ti	trace	trace	----
	100·00	100·00	100·00

This analysis shows that the salt was practically pure. The trace of titanium was found by testing with H_2O_2 and amounted to only ·0066 per cent.

Tantalum when treated with zinc and hydrochloric acid does not reduce. Niobium on the other hand forms apparently several reduction products or at least exhibits colors varying according to treatment. When zinc is added to a dilute hydrochloric acid solution of niobium, a blue color is formed in the cold; if the acid is strong a brown color is obtained which, if the acid is allowed to act on the zinc until nearly neutralized, changes to blue and an indigo blue precipitate separates out. When heated to 100° only quite dilute acid solutions give a blue color which speedily turn brown. Those containing more acid give a brown color at once. If sulphuric acid is used instead of hydrochloric, the blue color appears at first, but on heating with much acid this passes into a brown differing slightly in color from that produced in the hydrochloric acid solution. A grass-green color is often obtained in the cold, with both sulphuric and hydrochloric acids, which appears to be intermediate between the blue and the brown as the blue passes into green and this into brown. All solutions strongly acidified with sulphuric or hydrochloric acid give on heating a dark brown color, which evidently indicates the lowest reduction attainable, while the blue color marks a higher oxide than the brown or else an incomplete reduction.

The solution reduced with sulphuric acid and zinc is much less stable than that with hydrochloric acid, for on pouring it while warm into water, if the amount of reduced niobium is sufficient, an evolution of hydrogen takes place from the decomposition of the water. With hydrofluoric acid and zinc a violet color is produced similar to that given by titanium with zinc and sulphuric acid. Under similar conditions titanium gives a green color.

The first attempts at a quantitative determination of niobium were made with sulphuric acid solutions of $NbOF_3 2KF$, as sulphuric acid is better suited for titration with potassium permanganate than hydrochloric. It was found, however, that the amount of reduced niobium was very far from constant. More

constant results were obtained by pouring the reduced solution into ferric sulphate, but these varied too widely to give any promise of a satisfactory method. Hydrochloric acid was then tried and iodine solution added till a drop gave a blue color with a drop of starch solution, then sodium thiosulphate solution in slight excess, then a few drops of starch solution and iodine added till a blue color appeared. It was found, however, that a dark brownish color was formed near the end of the titration which so obscured the blue of the starch that very unsatisfactory results were obtained.

I then tried potassium dichromate for titrating, pouring the reduced solution into ferric chloride but without success.

Potassium permanganate was then returned to and manganese sulphate or magnesium sulphate added to prevent the action of the hydrochloric acid on the permanganate. It was afterward found that by sufficient dilution the end point could be obtained with all the accuracy desirable without the addition of either magnesium or manganese sulphates. The results are shown in the following table. The reduction was assumed to be to Nb_2O_5.

Amount of acid used.	Amount of $NbOF_3 2KFH_2O$.	Time of reduction.	Percentage of Nb_2O_5.
50 c. c. HCl sp. gr. 1·1	·5155	½ hour	34·24
"	·4652	"	35.21
"	·4932	"	35·58
"	·5900	"	34·90
"	·5561	"	34·50
"	·6614	"	35·24
"	·4926	1½ hour	34 01
"	·5896	"	34·60
40 c. c. "	·4982	½ hour	34·27
"	·4161	"	34·13
30 c. c. "	·5291	½ hour	33·56
50 c. c. " (conc.)	·5219	½ hour	37·68
"	·8122	"	38·41
"	·4256	"	36·74
"	·7152	"	37·65
Contained about ·5 gr. $TaF_5 2KF$. 25 c. c. " (conc.)	·4421	"	36·97
"	·5162	"	37·54
"	·3910	"	37·40
"	1·0592	"	38·07
"	·8890	1 hour	37·56
"	·9274	"	35·90
"	·6734	½ hour	38·58
"	·6861	"	38·78
"	·5980	"	38·30
"	·5828	"	38·70
"	·7611	"	37·68
"	·6530	"	38·07
In the above analyses the fluorides were dissolved in water and the acid added. In the following concentrated acid was added directly to the fluorides	1·1023	"	39·03
	·8395	"	38·86
The amount of Nb_2O_5 corresponding to the niobium in the $NbOF_3 2KFH_2O$ is			44·48

The foregoing series of determinations show that the reduction of the niobium is quite constant for a given strength of acid depending not on its amount but on its strength. The determinations were made by dissolving $NbOF_3 2KF$ in water and adding the indicated amount of acid. The first eight determinations, where 50 c. c. of dilute acid were used, give an average of 34·78. With 40 c. c. the same amount of water was used to dissolve the fluoride, the strength was consequently less and the average lower, being 34·20. With 30 c. c. 33·56 was found. When concentrated acid was used the amount of water required to dissolve the fluorides was small in comparison with the amount of the acid in solution, so that the amount of water used exerted but little influence on the reduction, but the increased strength of acid raised the average to 37·80. The results obtained when concentrated acid was used to dissolve the fluoride are higher still, the average being 38·94.

Thus we have

For 30 c. c. HCl sp. gr. 1·1	33·56	per cent Nb_2O_5
40 c. c. " "	34·20	" "
50 c. c. " "	34·78	" "
Concentrated HCl	37·80	" "
Fluorides dissolved in conc. HCl	38·94	" "

It appears therefore that the amount of reduction increases with the concentration of the acid. The formula for an oxide corresponding to the reduction in the last case would be Nb_8O_{19}. Marignac sought to obtain a formula for this oxide in the same way and obtained Nb_3O_8. This is very nearly equal to Nb_8O_{19} since, for eight atoms of niobium there would be thirteen and a third atoms of oxygen according to his formula. It is probable that neither of these oxides represents the oxide formed, but that a partial reduction has taken place as will appear from the results obtained from niobic acid in the following manner. Ten grams of $NbOF_3 2KF$ and five grams of $TaF_5 2KF$ were accurately weighed and heated with sulphuric acid in a platinum dish till all the hydrofluoric acid was removed. The acid solution was poured into water and precipitated with ammonia, washed by decantation and then thoroughly dried at 100° C. Weighed portions were then ignited and the total amount of mixed oxides of tantalum and niobium determined. The percentage of niobic oxide in these mixed oxides was calculated from the relative amount of the fluorides of each metal taken. In this way it was found that the mixture of tantalic and niobic acid precipitated and dried at 100° contained 47·36 per cent of Nb_2O_5. Weighed portions were then dissolved in as small an amount of hydrofluoric acid as possible and 50 c. c. of concentrated acid added and the reduction carried on at a temperature

of about 80° C. for three quarters of an hour. The amounts obtained were as follows:

Am't of mixed oxides taken.		Amount of Nb_2O_5 found.
·6400		46·99
·6652	Nb_2O_5 present	47·45
·7455		46·70
·7663	47·36 per cent.	46·64
·8323		46·97

In the above determinations the reduction was evidently to Nb_2O_3. Marignac states that alkali fluorides impede the reduction, and this would explain why the reduction in the foregoing determinations was complete while in those where the potassium fluoride of niobium was used it was incomplete; as the amount of alkali fluoride was always in the same proportion to the amount of tantalum and niobium constant results might be expected, but it is remarkable that so small an amount of alkali fluoride should exert so great an influence on the reduction, and that the hydrofluoric acid added to dissolve the niobic acid did not also interfere with the reduction. Two analyses were made in order to throw light on this point by adding weighed amounts of potassium fluoride to a mixture of tantalic and niobic acids free from fluorides and containing 45·99 per cent of Nb_2O_5.

Weight of mixed acids.	Weight of KF.	Nb_2O_5 found.	Nb_2O_5 present.
5696	·0900	43·83	45·99
5405	·3728	43·87	

From this it would appear that the *amount* of alkali fluoride exerted no influence, but that its *presence* did. In this case, however, the reduction is proportionally greater than when $NbOF_3 2KF$ was used.

The influence of titanium was next studied. Titanic acid was treated exactly as the niobic acid and the following results were obtained.

TiO_2 found by reduction and titration.		Present.
20·38	20·36	20·48

In order to determine whether both niobium and titanium would reduce together as well as separately, the oxides were mixed together and the niobium determined by deducting from the amount of permanganate used the amount necessary to oxidize all the reduced titanium and calculating the niobium corresponding to the balance. In this way I obtained the amounts given below.

Mixture of three acids.	Titanic acid present.	Nb_2O_5 present.	Nb_2O_5 found.
1·1798 gr.	·0859 gr.	·4928 gr.	·4907
·8145	·0687	·3357	·3314

For the determination of titanium in the presence of niobium the method proposed by A. Weller (Berichte, xv, 1882, 2, p. 2592), appeared most suitable. It depends upon a comparison of the color produced by hydrogen dioxide in an acid solution of titanic acid, with the color of a solution containing a known amount of titanium. A. Weller, in describing his method, calls attention to its applicability to the determination of titanium in the presence of tantalum and niobium, but says he has not tried it in this case. I therefore undertook to determine the best manner of applying it. I found that it was necessary to use hydrofluoric or hydrochloric acid in order to keep the tantalum and niobium in solution when sufficiently diluted. I found that the first of these acids even in small amounts entirely prevented the formation of the color of titanium with hydrogen dioxide and that hydrochloric acid deepened it very greatly in proportion to the amount added. It is necessary, therefore, to have the solution free from fluorides, and to have the same amount of acid in the standard solution as in the solution to be analyzed. It is very difficult to obtain these conditions and I was entirely unsuccessful in my attempts to determine the amount of titanium in a solution containing much free acid. I succeeded in obtaining quite satisfactory results, however, by precipitating the strongly acid solution with a small excess of ammonia and then redissolving the precipitate with as little sulphuric acid as possible, the freshly precipitated niobic and tantalic acids being readily soluble in dilute acid.

In order to test the accuracy of this method a mixture of tantalic, niobic and titanic acids containing a known amount of each acid was dissolved in hydrofluoric acid in a platinum dish and the excess of acid evaporated off on the water bath. The fluorides thus obtained were dissolved in concentrated hydrochloric acid and poured into a glass flask of about 100 c. c. capacity, the platinum dish being rinsed out with concentrated hydrochloric acid. The solution and rinsings amounted to 50 c. c. Amalgamated zinc was then added and a piece of platinum and the solution allowed to reduce in a stream of carbonic acid for three-quarters of an hour at a temperature of about 80° C. During this process the greater part of the hydrofluoric acid was removed from the solution, going off as silicon fluoride. After cooling thoroughly the reduced solution was poured into a beaker and diluted to 350 c. c. with distilled water freshly boiled and perfectly cold. A standard solution of potassium permanganate was added till the solution, at first nearly black, became perfectly clear and a distinct pink color was produced by the addition of a single drop. To the solution containing the tantalum, niobium and titanium, ammonia was added in slight excess and then sulphuric acid till the precipitate produced by the ammonia dissolved entirely. In this way a solu-

tion was obtained containing a very small amount of free acid and practically free from fluorides. This solution was then diluted to 500 c. c., and 50 c. c. brought into a nesslerizing tube and 2 c. c. of hydrogen dioxide added. About 40 c. c. of water was added to another tube of the same dimensions and then 2 c. c. of hydrogen dioxide. A solution of titanic acid, prepared by evaporating potassium titanium fluoride with excess of sulphuric acid and diluting with water until 1 c. c. equaled one milligram of titanium oxide, was then run in until the color in the two tubes was nearly alike. They were then brought to the same volume and the standard solution of titanium added drop by drop till there was no longer any difference in color discernible. The number of cubic centimeters of the standard solution multiplied by ten gave the number of milligrams of TiO_2 in the solution analyzed. By calculating the amount of permanganate solution necessary to oxidize the Ti_2O_3 formed by reduction of this amount of TiO_2 the amount of permanganate employed to oxidize the niobium was found and from this the amount of niobium calculated. The tantalum was found by subtracting the sum of the niobic and titanic oxides from the sum of the three oxides. In this way the following amounts of each were found.

	Nb_2O_5	Ta_2O_5	TiO_2
Taken	·3357 gr.	·2246 gr.	·0687 gr.
Found	·3314 "	·2289 "	·0667 "

It is necessary that during the reduction the heat should not be too great, as the tantalic acid is liable to precipitate and to carry with it both niobium and titanium and the reduction consequently will be incomplete. If tantalum is not present the solution can be boiled without danger. In order to analyze a mineral containing these three elements the mixed oxides can be obtained in the usual manner by fusing the finely ground mineral with bisulphate of potassium, digesting with water, filtering, heating the residue with ammonium sulphide, washing to remove tin and tungsten if present, treating the residue with dilute sulphuric acid to remove iron, washing and igniting with ammonium carbonate. After obtaining the joint weights of the oxides, fuse with potassium bisulphate, digest with water, and the residue, washed free from sulphates, dissolve in hot hydrofluoric acid, evaporate nearly dry on the water bath and proceed with the reduction and determination as just described. An analysis of Branchville columbite by this method, gave the following results:

Ta_2O_5	18·95	19·44	Specific gravity
Nb_2O_5	60·95	60·46	5·73
FeO	12·86	12·95	
MnO	7·07	7·00	Oxygen ratio
			1 : 1·03
	99·83	99·85	

Marignac constructed a table of specific gravities of columbite which showed that in general the specific gravity increases with the amount of tantalum. The relations which he found hold good for this analysis.

ART. XLIV.—*Notes on the Surface Geology of the country bordering the Northern Pacific Railroad;* by J. S. NEWBERRY.

FROM Chicago through Wisconsin and Minnesota the Northern Pacific Railroad passes over an almost unbroken sheet of drift, which, though of great interest, has been so fully described in the able reports of Messrs. Chamberlin, Winchell and Upham, that nothing further need be said here in regard to it.

Going west from Duluth to Brainerd the line of the road for the most part lies in what is evidently the old deserted bed of a westward extension of Lake Superior. The ground is still low and swampy and much of the surface is formed of what is unmistakably lake sand.

At various points farther west true till is seen with its striated pebbles; and one such exposure at Audubon is within reach of every traveler. Beyond this, bowlders scattered over the surface and pebbles in the ditches continue as evidence of the transport of material from the eastern highlands. About Bismarck the bowlders though fewer are still not rare and are gathered in groups and trails, as elsewhere along the margin of the drift area, suggesting transport by ice floats. The last of these bowlders is seen at Sims, about twenty miles from Bismarck. From this point to the crossing of the Little Missouri one can hardly find a stone to throw at a bird or a shrub big enough for a tooth pick. This is an extension northward of that broad prairie area which I have crossed in many places farther south. Here, between the eastern drift and that from the Rocky Mountains, the soil is formed entirely by the decomposition of the underlying rocks, and wherever these are shales and calcareous sandstones, as they are throughout most of the Cretaceous formation, there are no outcropping ledges of rock; the country is smooth and stones of all kinds are scarce. This belt, which runs from the Mexican to the Canadian line, is prairie because of the dryness of the climate and not on account of the soil or the geological substructure; for between the "Cross timbers" and the Raton Mountains with a considerable variety of geology and topography, there are no trees except along the water courses, which, fed by the melting of the snows on the Rocky Mountains, are perennial and supply constantly the amount of moisture that is a necessity for tree growth.

The peculiar fineness of the soil of the northern portion of this belt has been supposed to have something to do with the prevalence of grass and the absence of trees, since in Illinois and Wisconsin, along the border line between the forest and the prairie, the levels where the soil is fine are grass-covered, while the swells and ridges, rocky or gravelly, carry trees; but as I have shown elsewhere, these local peculiarities of the soil, favoring, the first grass and the second trees, have to some extent caused the observed interlocking of prairie and forest. Farther west, with every kind of soil and geological structure, there are no trees, but everywhere grass, while east of the Mississippi and beyond the battle ground between the two forms of vegetation, all kinds of topography, soil and substructure are covered with forest. No one who has traversed the continent along several parallels of latitude and has studied the relations of vegetation to soil and geological structure will fail to find conclusive evidence that the influence which has determined the kind and quantity of vegetation in the varied topographic and climatic districts of the west is the rainfall.

The valley of the Little Missouri is deeply cut in a table land composed of the Laramie coal-measures, of which 200 or 300 feet with several seams of coal are exposed in the cliffs. Thousands of silicified tree-trunks are scattered over the surface and innumerable stumps are apparently standing where they grew, but no foreign material is anywhere visible. A few miles below the railroad crossing the valley expands and opens into the famous *Mauvaises Terres*, or "Bad lands of the Missouri." The course of that stream being here nearly east and west and the valleys of the tributaries north and south, these coalesce and form in the old lake beds picturesque but dangerous labyrinths.

As soon as one enters the valley of the Yellowstone he finds himself surrounded by transported material. Gravel and bowlders of crystalline, sedimentary and volcanic rocks form the bed and bars of the river, increasing in coarseness and quantity to Livingston, but in all this material I was unable to find anything that was to me even presumably of eastern origin.

Dr. C. A. White (this Journal, vol. xxv, 1883, p. 206) reports finding what he considers eastern glacial drift along the valley of the Missouri and that of the Yellowstone, but my search for such material was vain.*

The geology of the Yellowstone Park has been well described by Dr. Hayden and his assistants, Mr. W. H. Holmes and Mr. A. C. Peale, but I was surprised to find the traces of glacial action so widespread and unmistakable. It is probably not too

* As will be seen farther on, I found in the valley of the Missouri about the falls great quantities of drift with bowlders of fossiliferous limestone, quartzite, gneiss and granite, all remarkably like the eastern drift, but which I subsequently traced to their place of origin in the Belt mountains.

much to say that every valley of the Park was once filled with ice; for moraines, bowlders, glacial lakes, and more rarely glacial striæ give testimony on this question that cannot be disputed. Ice-borne blocks are seen on the sides of the Yellowstone valley below the mouth of Gardner's River, and south of Mammoth Hot Springs every depression has once held a glacier. Swan Lake is of glacial origin and is bounded on the south by a terminal moraine, while lateral moraines and striated rock surfaces mark the old ice level high up on the sides of the valley. Near Marshall's the road leads over a succession of great moraines of clay and bowlders which continue to and around the Fire Hole basin, and prove that this also was once largely filled with ice. From all I could learn the evidences of glacial action which are found here in the lowest portion of the Park may be traced through all parts of it.

DRIFT OF THE UPPER MISSOURI.

The Missouri River, formed at Gallatin City by the union of the Madison, the Gallatin and the Jefferson, traverses with a northwest and then northerly course the valley between the Rocky and Belt Mountains, and finds its way out to the plains by a long circuit around the northern bases of the Belt and Crazy Mountains, eastern outliers of the Rocky Mountain system. Cutting through barriers formed by interlocking spurs at the "Gate of the Mountains," the river enters an undulating prairie country which extends from the north side of the Belt Mountains to and beyond the Canadian line. All this region is occupied by a sheet of drift that in thickness and extent rivals that of the plains surrounding the Canadian highlands; but, as far as my observation extended, I found this of local origin.

At the Great Falls of the Missouri the underlying rock is exposed, but the drift-sheet comes up to the edge of the gorge and forms the low hills which stretch away to the east and north like the long swells of the ocean. In the valleys of the streams which come down to the Missouri from the Belt Mountains, the rock substratum is generally visible; but the intervening plateaus are covered with a sheet of drift that varies greatly in thickness as it is spread over a rock surface that was once deeply and irregularly eroded. For example, near the Upper Falls of the Missouri, where the banks of the river are solid rock and perhaps a hundred feet high, a tributary coming in from the south cuts across an old valley filled with drift, which extends almost to the present river channel. At its mouth this tributary has high rocky banks, but a few hundred yards above they are altogether composed of drift. This is a true till, thickly set with bowlders, some of which are two feet or more in diameter.

The bowlders are usually rounded, sometimes subangular, and are composed of gray or red granite, quartzite, Paleozoic limestone and a variety of eruptive rocks. The resemblance to the drift from the Canadian highlands is so great that I was only convinced of its local origin when I found all of its constituents in place in the Belt and Rocky Mountains. The granites were to my eye indistinguishable from those of the eastern Laurentian series. As I subsequently learned, they are of Archæan age, and nothing but careful microscopic examination will show them to be distinguishable, if they are so.

These facts lead me to suspect that the very careful and experienced observers who have reported the finding of eastern Laurentian bowlders on the flanks of the Rocky Mountains, 4000 feet above the sea may have been misled by this striking resemblance.

On the undulating surface of the table lands between the tributaries of the Missouri, large bowlders are occasionally seen, as in the States bordering the Great Lakes, and we passed one of these somewhat angular in form which had served so long as a rubbing-post for the buffaloes, recently abundant in this region, that its sides are all polished, and a deep furrow is worn around it by their feet.

THE GORGE OF THE COLUMBIA.

The gorge of the Columbia is one of the most impressive and interesting topographical features in all the picturesque West. It is cut with a nearly straight westerly course across the whole breadth of the Cascade Mountains, fifty miles, and its banks rise from 2,000 to 4,000 feet directly from the river side. Most of the material of which the walls are composed is basalt. This can be seen to form distinct layers, the products of different overflows from the great volcanic vents north and south of it. Cape Horn, a bold headland, shows a vertical face of trap nearly 500 feet in height.

No one who examines the gorge of the Columbia will fail to be convinced that it has been cut by the river. The general altitude of the mountains in which there are no other passes lower than about 5,000 feet, as well as the altitude of the lake deposits on the eastern side indicate that the work of cutting this channel began at a height not less than 3,000 feet above the sea. At this time the river must have had a fall of at least this number of feet into the valley of the Willamette; and to realize the conditions then existing, we must picture to ourselves a series of cascades of greater magnitude and more picturesque than any now known. This water-power was, however, busily engaged in cutting down the barrier, and in process of time it was so completely removed that a navigable canal was opened from the Dalles to the ocean. The

Western entrance to the gorge is now at tide-level and the lower part of the river is, like the Hudson, an arm of the sea. It is true that at present the "Cascades of the Columbia," form a serious interruption to the navigation of the river, for they are produced by a dam sixty-three feet high, which fills the channel for three miles. But this dam is of recent date, as we know, and has been caused by an avalanche from the sides of the gorge. Above it the river is simply a long lake, and in low water a series of stumps are seen coming up from below the water-level which belonged to trees that could never have grown in the places they occupy if the barrier of the Cascades had existed.

Steamboats navigate the Columbia from the Dalles down, with a transfer at the Cascades, and this is much the better route to take for those who would get a good view of the gorge with its imposing walls, its hanging forests and its picturesque waterfalls which leap 1,000 feet from the cliffs, to say nothing of the old Indian burial grove, and the multitude of silicified tree trunks at the Cascades.

The railroad is built along the face of the southern cliff, high above the water, and although it gives only a one-sided view of the gorge, it is generally chosen by travelers who prefer rapid transit to beauty of scenery.

ANCIENT GLACIERS OF THE CASCADE MOUNTAINS.

As is well known, the Rocky Mountains from New Mexico to British Columbia abound in evidences of ancient glaciation. The same is true of the Uinta Mountains, the Wasatch, the Sierra Nevada and Cascade Mountains. In the group of five snowy peaks called in Oregon the Three Sisters—because only three are visible from the Willamette valley, miniature glaciers were found by our party in 1855 at the heads of McKenzie's Fork and one of the tributaries of the Des Chutes, and on Mt. Shasta and Mt. Rainier are many true glaciers, of which some are several miles in length. But all the glaciers and snow-fields now existing on the Cascade Mountains are insignificant compared with those of the Glacial period. Then every gorge was filled with snow and ice, the broader and more irregular summits were covered with glaciers and these descended far below the present line of perpetual snow. Now in many localities and over many square miles the rock surfaces are planed smooth or grooved like a plowed field, and every projecting crest of volcanic rock, rough and ragged as it was, is rounded over and worn into a *roche moutonnée*. From the Three Sisters glaciers descend into the valley of the Willamette on the west and that of the Des Chutes on the east, and I traced glacial

markings from the snow line to a point 2,500 feet lower, where they pass under the alluvium of McKenzie's Fork.*

It has been claimed by Lecoq (*Les Glaciers et les Climats*) and following him by Professor Whitney and others (*Later Climatic Changes*), that the great development of glaciers during the Ice Period, such as those of the Canadian highlands, the Rocky Mountains, the Cascades and Sierra Nevada, was not the effect of a cold but a warm period, which increased the precipitation and consequently the snow-fall at all places where the temperature was low enough to cause it to take the form of snow. If this was all, however, the most extensive glaciers should be in the Alpine districts of the tropics or temperate zones wherever the precipitation is most abundant and the temperature low enough to produce perpetual snow. But the great glaciers of the present time are not on the Andes, the Himalayas or the Alps, but on Greenland and the Antarctic Continent where the climate is very cold and the amount of precipitation small.

We also find on the summits of the Cascades a demonstration of the fallacy of this view; since here some of the mountains rise 14,000 feet above the sea and the line of perpetual snow is not over 7,000 feet, while the annual precipitation is greater than in almost any other portion of our country. In fact the snow accumulates in such quantity that even in mid-summer it reaches down to where it is met and opposed by a vigorous forest growth—the product of a high temperature It is evident that no elevation of temperature, though it should increase the evaporation on the Pacific and the rain-fall on the coast, would cause the renewal of the ancient glaciers; but with a depression of temperature which should continue the present winter conditions through the year, the precipitation remaining the same, the accumulation would soon cover the mountain summits with snow and ice and bring the glaciers down to their old limits.

THE LOWER COLUMBIA.

The country bordering the Lower Columbia is too well known to require description. I am impelled, however, to refer to one or two points in its physical structure which are of special interest when brought into connection with facts of similar import observed in the region about Puget's Sound. I have said that the Lower Columbia is an arm of the sea. It is in fact a deep river valley which has been flooded by an influx of the sea caused by subsidence. This brings tide-water to the foot of the falls of the Willamette at Oregon City, and to the Cascades.

It requires no argument to prove that such a channel could not have been cut unless by a rapid stream flowing into the

*Pacific Railroad Report, vol. vi, Part II, Geology, p. 42.

ocean when it stood at a lower level. Whether the change in the relative level of land and sea here remarked was part of a general movement which produced the influx of the sea into the fiords which fringe the northwest coast; and whether this is not a part of a still grander movement that flooded the old excavated valleys of the James River, the Potomac, the Schuylkill, the Hudson, the St. Lawrence and the Saguenay and at the same time filled the fiords of the northeastern coast, are questions which cannot now be fully answered but are worth considering.

It will be noticed that the general plan of the topography of this part of the coast is altogether similar to that of California; namely, the great wall of the Cascades bordered on the east by the Willamette and Cowlitz valleys, and the Coast Mountains along the sea shore, are reproduced farther south by the Sierra Nevada, the great California valley and the Coast Ranges. And these features are not only physically similar, but geologically identical; the Cascades being the northern continuation of the Sierra Nevada, the more modern Coast Mountains being continuous, the great trough between them essentially one, but filled at its center by a mass of mountains.

SURFACE GEOLOGY OF THE PUGET'S SOUND BASIN.

The name Puget's Sound is made in popular use to cover all the peculiar group of inlets and tideways which lie immediately east of Vancouver's Island,—Puget's Sound proper, Admiralty Inlet, Hood's Canal, etc. These occupy the northern extension of the great Columbian valley, which, like its counterpart in California, lies between the Coast ranges and the Cordilleras. Farther north still this depression is deflected toward the northwest by a change in the trend of the Cascade Mountains and the representatives of the coast ranges on Vancouver's Island.

In Washington Territory the Coast Mountains are higher than in Oregon and have received the local name of the Olympian range, of which the highest summit is called Mt. Olympus. This range terminates somewhat abruptly but is apparently continued in the mountains of Vancouver's Island. Through the gap between these and the Olympian range a deep channel is cut, now an arm of the sea, called the Strait of Juan de Fuca. In former times, when this portion of the continent, and probably the whole northwest coast, stood higher above the sea, this Strait was the valley of a great river which drained most of the western slope of the Cascades in Washington Territory, and had as branches the Skagit, Snoqualme, Dwamish, Puyallup, Nisqually and various minor streams. During the Ice period this hydrographic basin was filled with a great glacier made up of contributions from all the surrounding moun-

tains. It flowed out to sea by the Strait of Fuca, but this channel was far too narrow for it and it spread over all the southern portion of Vancouver's Island, planing off, rounding over or deeply scoring the rocks in its passage. As the glaciers retreated they left behind a sheet of drift several hundred feet in thickness, partly water-worn and stratified, partly unstratified bowlder clay with striated pebbles, of which the surface was nearly level. In process of time the draining streams had cut in this plain a series of valleys all tributary to one which led out through the Strait of Fuca to the ocean. After perhaps some thousands of years, during which the excavation of these valleys progressed, a subsidence of the land or rise of the ocean caused the water to flow in and occupy the main valley and all its tributaries up to the base of the mountain slopes.

Such in few words is the history of the formation of this remarkable system of inlets. They are simply the flooded valleys of a great river and of the branches that formerly joined it but now empty into the extremities of the finger-like inlets that have partially replaced them.

There are but few localities in Puget's Sound basin where the rocky substratum rises so as to be visible above the water level. Along the northern and western margin on Vancouver's, Sucia, Orcas and Whidby Islands, and at Chuckernut's and Sohome the rock appears, but at Tacoma, Steilacoom, Seattle, Port Madison, Port Townsend, and it may be said generally about the Sound, the shores are steep bluffs, 100 to 150 feet in height composed of drift alone. From the cliffs at Port Townsend and Tacoma, I took sub-angular scratched and ice-worn pebbles as characteristic and convincing as any to be found in the bowlder clays of the eastern States.

The subsidence which caused the sea water to flow into the subaerially excavated valleys of Puget's Sound also filled the channel of the Columbia, the Cascades and the system of fiords, of which these are representatives, that fringe the northwest coast. We have evidence, too, that the area occupied by the sea was at one time much more extensive than now, for all the country immediately about Puget's Sound is marked with a series of marine terraces which Mr. Bailey Willis, who studied them carefully when connected with the Transcontinental Survey under Professor Pumpelly, tells me can be traced to a height of 1600 feet above the present ocean level. These terraces are conspicuous on the low divide which separates the valley of the Cowlitz from the basin of Puget's Sound; and here, as over much of this region, the ground is covered with pebbles and water-worn bowlders, the product of the long continued dash of the shore waves on a slope composed of drift materials. In the advance and recession of the shore line, the

finer materials have been mostly washed away, and the stony surface has little agricultural value. Fortunately it is well adapted to the growth of trees, and the splendid forest which covers it is perhaps an equivalent for all it has lost. The facts here given show why the cultivation of the soil in Washington Territory is limited to the narrow belt of modern alluvium along the streams, and indicate that coal mining, the fisheries and the lumber industry must be in the future as they now are, the most important sources of wealth.

MODERN GLACIERS OF THE SIERRA.

From the Willamette Valley and Puget's Sound grand views are obtained of the great snow peaks of the Cascade Mountains; the Three Sisters, Mt. Jefferson, Mt. Hood, Mt. Adams, Mt. St. Helens, Mt. Tacoma and Mt. Baker. Of these, Mt. Hood has an altitude of 11,225 feet, Mt. Adams 12,250, and Mt. Tacoma 14,400. In Colorado and California there are a number of summits of equal absolute altitude, but they have nothing like the relief above their surroundings that these have; carry far less perpetual snow, and in every way are less impressive. In Washington Territory the line of perpetual snow on the west side of the mountains is about 6500 feet; on the east side, several hundred feet higher. Mt. Tacoma carries therefore about 8000 feet of snow. Below this it is covered with a dense forest. As none of its foothills rise to the height of 2000 feet above the sea and are invisible at a distance, from many places about the Sound practically the whole of the mountain is seen at one view; a gigantic cone, 14,000 feet in height, apparently rising directly from the sea level. Mt. Shasta has the same altitude, and as seen from Scott's valley is wonderfully impressive, but it is situated farther inland and farther south, its base is higher and it has less snow, and is therefore somewhat less imposing. It is not too much to say then, that no other mountain on this continent and none in Europe rivals Mt. Tacoma in grandeur and beauty, and it is doubtful whether in the world there is any that produces a profounder impression upon the beholder. Mt. Hood, as seen under favorable circumstances from Fort Vancouver, especially when reflected from the lake-like surface of the Columbia, is as beautiful but far less grand.

Though appearing in the distance so smooth and symmetrical, Mt. Tacoma has been found to be a ragged and compound mass consisting of three conspicuous summits and many subordinate peaks, with precipices 2000 to 3000 feet in height and deep gorges which make the ascent difficult and even dangerous.

It has been ascended, however, several times, and its labyrinths sufficiently explored to prove that it carries from eight to twelve glaciers, some of which are many miles in length and will bear comparison with those of the Alps.

Every traveler who enters Puget's Sound region from the south is sure to be struck by the turbid milky appearance of the water of the Cowlitz River along which the railroad runs for miles. This character it shares with all streams that drain glaciers, and which has caused the Swiss mountaineers to give to the waters of such streams the name of *Gletscher Milch.* Its turbidity is due to the sediment produced by the constant grinding action of these enormous masses of moving ice set with stones upon their beds, and attests the sometimes disputed efficiency of glaciers as eroding agencies. The Puyallup, White River, and other streams, which come down from Mt. Tacoma, are alike milky, and each shows that one or more glaciers are continually grinding away at its head. On the contrary, the streams which do not come from glaciers and are supplied by rain only, and that filter through the decaying vegetation of the dense forests, carry very little sediment and that chiefly carbonaceous matter. These are clear but brown, and the contrast which the water of such streams presents to that of the rivers which drain the glaciers is very striking and justifies the names borne by two such of Black and White Rivers.

It has been contended by some writers, as has been mentioned, that the extension of glaciers in former times was due simply to an increase in the amount of precipitated moisture, but it is easy to see that the heavy rain-fall of Washington Territory might be increased indefinitely with no considerable elongation of the glaciers. But even with the rain-fall remaining as it is, if a depression of temperature should take place carrying the present conditions of winter through the year, the glaciers would soon creep down into their old beds, fill all the valleys of their draining streams and finally coalesce to form one grand glacier which would flow out through the Strait of Fuca to the ocean.

Following the coast northward from Puget's Sound we find the glaciers coming down lower and lower until in Alaska they reach the sea level. No one can claim that this is because the precipitation is greater there, since observations show that it is not, but every candid man will acknowledge that it is because at the north the temperature is lower. He must also accept these facts as a demonstration *that a prime factor in the production of the phenomena of the Ice Period was a secular depression of the temperature.*

ART. XLV.—*Rainband Spectroscopy;* by LOUIS BELL.

IT is now more than ten years since Professor Piazzi Smyth pointed out that the absorption bands of aqueous vapor in the solar spectrum were likely to be of considerable service in meteorology; but although his observations were evidently successful and have been often repeated with equally good results, little progress has been made in the practical application of the principle. This lack of results appears to be due to two causes. First, as the method seemed to offer an easy way of predicting the weather, it at once fell into the hands of the would-be weatherwise who understood it very imperfectly and were thoroughly incompetent to use it. The successful often made the wildest claims for it, and those less skillful or fortunate were active in denunciations, even deriding it as "an optical illusion strengthened by long practice." Secondly, there were real difficulties in the way of its application. Nearly all observations of the rainband have depended upon eye estimations of its intensity, unsatisfactory at their best and doubly so when complicated by long intervals, clouds, and widely varying conditions of illumination. The rainband is a small object in the instruments generally used for the purpose, and it is no easy matter to compare it with such a vague and variable thing as a mental scale of blackness. The reference to the Fraunhofer lines is open to nearly as much objection, since their apparent intensity is liable to vary with the light, width of slit and general condition of the spectroscope to an extent which renders them very uncertain standards for scientific purposes.

The first mentioned cause is an unfailing concomitant of every discovery that smacks of popular science; the second is due only to the nature of the observation itself and can be removed with comparative ease. The object of this paper is to call attention to a device by which something like quantitative accuracy can be secured in the study of the rainband, and to the general methods which appear to give the best results in this investigation, which, it is to be hoped, will prove of permanent service to meteorology.

The desideratum is evidently a definite and trustworthy scale of variable blackness, extending over quite a wide range, and easily comparable to the rainband. A direct photometric measure of the intensity of the absorption band would of course be valuable, but is an observation too complicated and delicate for everyday use. The measurement could be made however by using a standard of light as one of the sources of illumination in the spectro-photometer of Vierordt ("Die An-

wendung des Spectral-apparates") or some modification, like that described by the writer (American Chemical Journal, vii, No. 1). The ideal scale therefore should be constructed so that the absolute intensity of its various readings could be found by the above or some other method.

Janssen and others have tried various rude methods of estimation, but the only scientific instrument for measuring absorption lines yet devised is that due to Mr. C. S. Cook, and described by him in "Science," ii, 488. His plan consists, in brief, of forming diffraction fringes in the field by a silk fiber placed a trifle beyond the focus, and varying their intensity by moving the fiber to or from the focus by means of a screw collar. The fringes thus produced resemble the lines of the rainband quite closely, and form a very reliable and delicate scale. Its successful use, however, requires a skilled observer and much care, and its indications cannot be reduced to absolute measure except by a comparison with some absorption line which can in turn be evaluated with a spectro-photometer, itself by no means an easy matter. While this method is very effective in measuring the individual lines of the rainband some plan for measuring the band as a whole seemed desirable, and, after some casting about, the writer determined to give a careful trial to the interference bands produced in the spectrum by a crystal in polarized light. So far as known, this method has not hitherto been used.

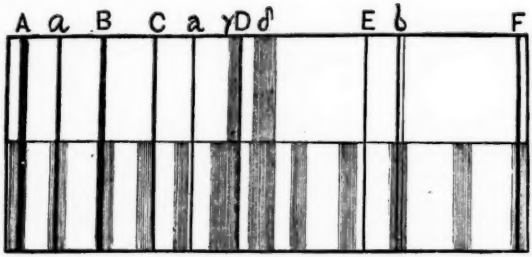
The instrument used was a direct-vision spectroscope by Schmidt of Berlin, which gave a very bright spectrum with moderate dispersion and beautiful definition. Its five prisms polarized well enough to make it a very efficient analyzer. A bit of selenite having a well defined natural edge was then split down till the interference bands produced by it were about as wide as the maximum rainband as seen in the above instrument. The plate thus prepared was placed immediately in front of the slit, covering, however, only half the field. The usual cap of the spectroscope was removed, and replaced by a tube graduated to five degrees and carrying a 9^{mm} Nicol prism. Thus equipped, a long series of preliminary experiments were made to settle upon the best method of observation and adjustment of instrument.

Finally the following plan was adopted. The thickness of the selenite plate was so adjusted that the bands appear as in fig. 1, one of them being situated about the average width of the rainband on the less refrangible side of D, i. e. in the red. Then the Nicol prism was turned till the interference band was of the same intensity as the rainband, when the field appeared of the same brightness from the red side of the interference band to D. In this method of observation it is quite as well

to have the selenite plate cover the entire slit, as the field is then uniform and the obtrusive black line produced by the edge of the plate is absent.

In passing it must be remarked that the nomenclature of the atmosphere lines is in a state of confusion thrice confounded. Each investigator seems to have numbered or lettered them to suit his taste. Only two telluric groups of lines have designations which are generally received, the band at w. l. 628 (α) and that at w. l. 578 (δ). In this state of affairs the writer would suggest that for sake of brevity it would be well to apply the letter γ to the well known rainband near D, reserving

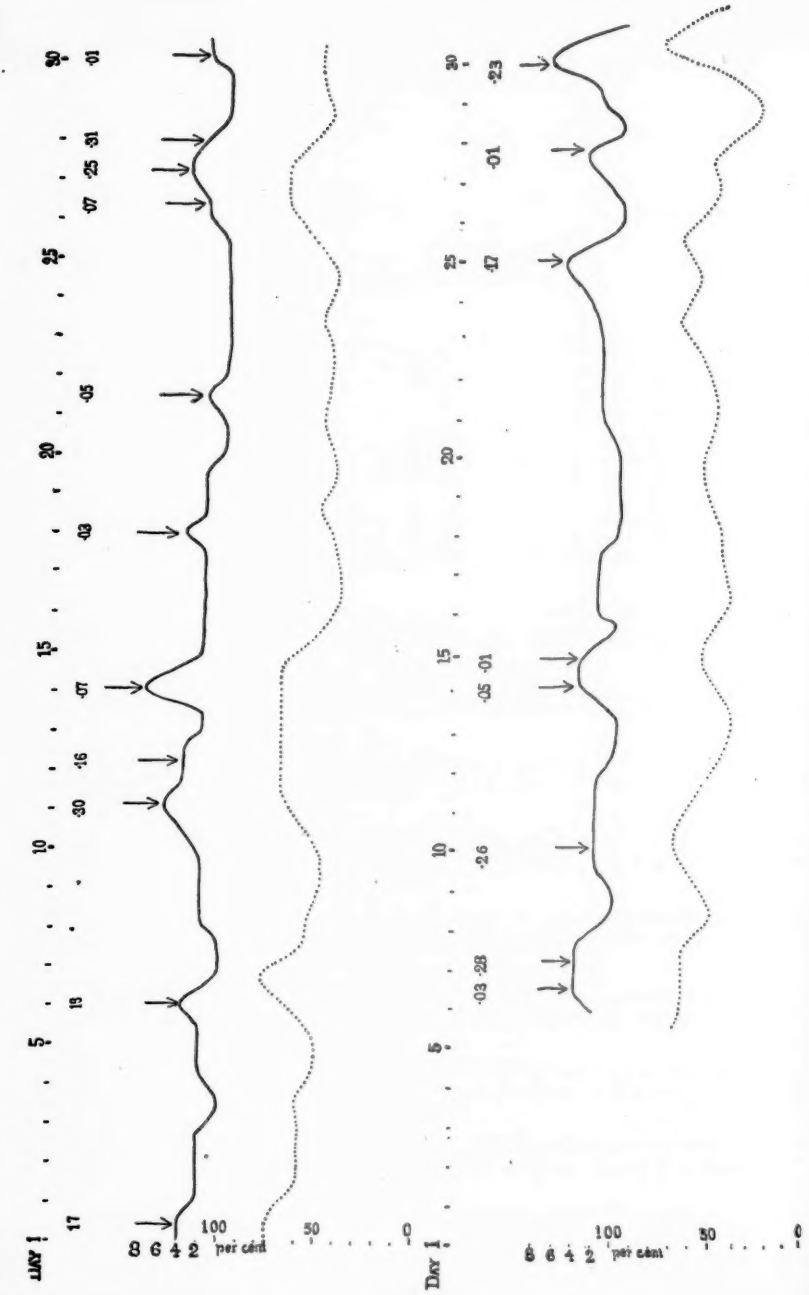
1.



β for the faint band given in Ångström's chart between α and D, and using Brewster's lettering for the more refrangible part of the spectrum. Then in referring to the individual lines that go to make up γ or any other of the bands it would be well to simply number them in order of their wave length $-\gamma 1$, $\gamma 2$, etc. And a careful map of γ is badly needed.

After being arranged as above, the spectroscope was used constantly for six months with complete success. The place of observation was Baltimore, Md., a location well calculated to give rainband observations a severe test, by reason of a climate more than usually variable. Having arranged a satisfactory scale, the point to be determined was, how far rainband observations alone are to be trusted as prophetic of the weather, and how they should be taken with a small instrument like the one used in order to secure maximum efficiency.

As to the first point the annexed chart answers the question. An observation was taken at 8 A. M. and another at 2 P. M., usually in the western sky. No other instrument was used to confirm the indications of the spectroscope. From day to day the instrument was now and then readjusted as regards slit, focus, etc., and there was no difficulty in securing identical scale readings after such readjustment. The instrument polarized too well, so that the interference band could be made


Day 1
17
13
-07
-16
-30
-05
-03
-07
-25
-31
-01
Day 1
-03
-28
-26
-05
-01
-17
-01
-23
100
50
0
per cent
8 6 4 2

much blacker than was ever necessary. Consequently a small rotation of the Nicol would duplicate the strongest rainband and the scale was somewhat limited in extent. The tube carrying the Nicol was graduated to give a scale of about eighteen grades of intensity, but for the above reason only eight could be used, which however proved sufficient to give very good results. The rainfall and relative humidity for the period covered by the chart were obtained from the Signal Service station at Baltimore. In the chart the upper curve gives the variations in γ from day to day, the arrows being placed to indicate the time when a rain began, and the amount of rainfall being annexed. The dotted curve below shows the per cents of relative humidity for the same period. During the time represented there were nineteen rains, of which number fourteen (73 per cent) were distinctly predicted from two to thirty-six hours before their occurrence by an increase in the intensity of the rainband. On grouping the rainfalls in the case of a continued storm, like that of the last week of March, there were fourteen rains, of which thirteen (93 per cent) were predicted. In only one case did a rain come entirely without warning—the shower of March 18, which drifted up suddenly between observations. In one or two other cases rain fell shortly after the morning observation; but on a careful review of the observations, it appears that during the entire six months about eighty per cent of the rains gave fair warning through the spectroscope. This is a very satisfactory degree of efficiency for a small instrument. It will be noticed that in the chart there appears no very obvious connection between the strength of the rainband and the amount of rain. Now and then there is a rough correspondence, but that is all. A good reason for this is found in the fact that now and then an observation would be taken during a previously predicted storm and thus γ would be abnormally strong, as it is generally during a rain. The curve of relative humidity corresponds quite closely with the rainband curve, though in general its maxima and minima are some hours later. The occasional discrepancies are undoubtedly due to the fact that while the hygrometer indicates only the lowest layer of aqueous vapor, the spectroscope sums up everything along the line of sight and thus indicates vapor in the upper strata of the atmosphere entirely out of reach of the hygrometer, while on the contrary an earth stratum quite dense enough to affect the latter instrument would be frequently too slight to make itself apparent as a rainband, particularly in a small instrument.

In this integrating power of the spectroscope lies its strength, and unfortunately also its weakness as a meteorological instrument. While it shows with considerable accuracy the total

amount of aqueous vapor in the entire thickness of air in the direction of observation, it tells nothing of its distribution along that direction. Thus without any increase in the rainband there may be a precipitation of rain due to a descending mass of vapor. So also clouds may or may not affect the rainband, though as a rule they do. The amount of vapor present is often quite independent of the amount and kind of visible clouds. Now and then the spectroscope will show dense masses of vapor where the eye can detect at most only the lightest cirri. Again, toward the end of a storm the sky may frequently be overcast with threatening clouds when the rainband clearly shows that the storm is over. Indeed the close of a storm is indicated quite as certainly as its beginning, and in this fact lies one of the great advantages of the spectroscopic method. A typical case is shown in the storm of May 1st, when the hygrometer reached its maximum some twelve hours after the rainband had fallen far enough to indicate the cessation of rain.

It is difficult, if not impossible, to designate the intensity of rainband that may be regarded as a sure precursor of a storm. Certainly no general rule can be laid down, for at present no two scales are alike and each locality probably has its own peculiarities. For the instrument used by the writer in Baltimore, a rainband corresponding to 4 of the scale generally meant rain within twenty-four hours. With the limited scale possessed by the instrument it was best to register the faint traces of a rainband as 0− too small to measure easily, although in a larger spectroscope one might venture on an estimate. It is very desirable that the readings of intensity should be reduced to an absolute scale, in which case observations taken at all points would be comparable and might lead to the discovery of the laws which govern the distribution of aqueous vapor. A knowledge of these could hardly fail to be of great value to the science of meteorology.

With the polarization scale herein described it is quite possible to determine the value of each scale division in per cent of light absorbed, by a careful comparison by means of the spectro-photometer, since the interference bands are wide enough to be easily measured. The coefficients of absorption once determined it would be possible to reduce them to terms of standard column of aqueous vapor, and then the problem would be well in hand and rainband observations would mean something more than mere qualitative estimation. Until these quantitative measurements are generally made, the spectroscope can be of comparatively small service except as an aid to the prevision of local storms.

For this latter purpose it is certainly effective and when used

in conjunction with the usual meteorological observations, can hardly fail to give indications of real value. Alone it appears to be of about the same order of usefulness as the barometer alone and unaided, but in connection with other instruments it certainly deserves to be generally used, and ought to be added to the equipment of meteorological stations. Its cost is quite small—an instrument like the writer's, fitted with a similar scale, costing not more than $20. In practice a pile of glass plates is cheaper and better than a Nicol prism, since it polarizes less perfectly and thus allows the use of a more extended scale.

If an untrained observer begins rainband observations he is almost sure to be, at first, disappointed with the results. He procures a small pocket instrument of insufficient dispersion and goes to work under the impression that a daily observation will enable him to predict the weather for the next twenty-four hours or more with almost unerring certainty. Naturally he fails, and the more thoroughly he has believed the claims made in various popular articles the more bitterly he abuses the method. And very absurd claims have been made for it. There may be some gifted persons to whose eyes the rainband spectroscope becomes an oracle to reveal the meteorological future, discriminate between hail, snow and rain, designate the amount of each, predict the electric potential of an approaching cloud, indicate the per cent of ozone (!) in the atmosphere, and in general answer the scientific prayers of the astute suppliants. But the writer is not one of this fortunate number. If there is any method of predicting the kind of precipitation which is to occur, or of discovering the aforementioned potential, he would like to see it demonstrated in black and white, so that it will not require the eye of faith to comprehend it.

The rainband spectroscope, like most other scientific instruments, is capable of giving good results in competent hands, but there is no jugglery about it, neither is it the universal solvent of meteorological difficulties, and success in its use can be obtained only by frequent and careful observations, accompanied if possible by observations with other instruments.

For practical work one of the larger pocket spectroscopes should be chosen, giving a bright well defined spectrum with a moderate amount of dispersion. For use with the scale described the dispersion should not be great enough to resolve the rainband into distinct lines, but should show it simply as a dull band, so that it will be comparable to the interference bands. If the individual lines are to be studied a much larger dispersion is needed—enough to divide D without difficulty. The instrument should be used with a rather narrow slit and

should be focused for sharp definition of D; γ will then appear as a narrow shading along the red edge of D if the weather is fine, or a dark stripe if it is rainy, and can be very easily compared with the scale.

The observations should be taken not less than twice a day, one of them being as late in the afternoon as practicable, since changes are so apt to appear about sunset. If convenient, observations should be taken at various altitudes. For a single altitude 20° is perhaps as good as any. As to the question of direction, it is a matter to be guided by local conditions. The illumination should be as good as can be attained without looking directly at or near the sun, and a quarter of the sky should be chosen where this condition is fulfilled. Observations in all directions are to be desired; but if only one is chosen it should preferably be the one from which storms usually come. An additional observation in the direction of the wind is likely to be useful. Observe systematically the same directions and altitudes. Avoid cumulus clouds when practicable, as they are likely to increase the rainband without a corresponding probability of rain. Employ clear skylight, if possible without much variation of direction or altitude.

More trust is to be put in a sharp rise or fall of rainband intensity than upon absolute intensity, since the latter is likely to average differently in various locations and be subject to various modifying factors, while the former in nearly every case means a definite change. With these and other precautions which will suggest themselves to individual observers, the rainband spectroscope is capable of giving very good results, and the field of investigation is a decidedly promising one.

For the convenience of those interested in the subject a brief bibliography is appended comprising the more important publications which have appeared upon the subject. A few of them refer to telluric lines in general.

Nature, xii, 231, 252; xiv, 9; xvi, 389; xxii, 194. Piazzi Smyth.
Edinburgh Astronomical Observations, xiv. Smyth.
Scottish Meteorological Soc. Jour., N. S., Nos. 51, 52. Smyth.
Madeira Meteorologic. Knowledge, ii, No. 48. Smyth.
Proc. Roy. Soc. Edinburgh, xii. Mill.
The Rainband (Hilger, 1883). Mill.
The Use of the Spectroscope in Meteorology U. S.
Signal Service Notes, No. iv, 1883. Upton.
Comptes Rendus, lxiii, 293, xcv, 885. Janssen.
A Plea for the Rainband (Browning, 1881). Capron.
Science, ii, 488. Cook.
Journal de Physique (2me ser.), ii, 58, iii, 109. Cornu. iii. 5. Thollon.
How to Foretell the Weather with the Pocket Spectroscope. (Chatto and Windus, 1884.) Cory.

ART. XLVI.—*A new Genus of Chazy Sponges, Strephochetus;* by Professor HENRY M. SEELY.

THE Chazy rocks of the lake towns of Addison County, Vermont, afford a fossil form which, so far as is known to the writer, has not been heretofore described. That it should have been so long neglected is the more remarkable since it is an excellent guide to some layers of the Chazy when other well known fossils are obscure or wanting.

The nearest approach to an illustration of this form is found in the Geology of Vermont, vol. i, p. 277, fig. 175, where *Phytopsis tubulosum* is figured. In the text, attention is called to a horizontal section of the stem; and the concretionary arrangement of the calcareous matter is pointed out. No perpendicular section is given.

It was assumed on a recent examination that the form was of animal origin and a provisional name indicating that it was a Stromatopora was assigned it. A more extended examination however does not confirm the first impression. The size of the object favors its complete inspection, it being so small that a section of the entire fossil cut in any direction can be placed on a slide and put upon the stage of the microscope.

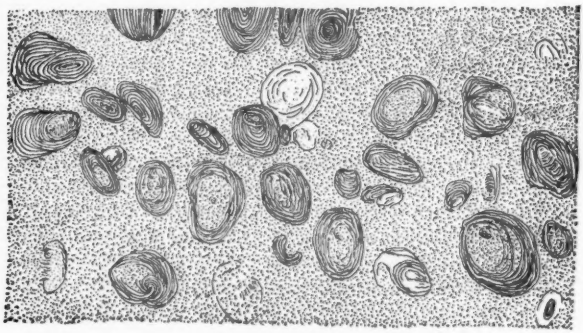
The mass is seen to be mostly made up of concentric layers of material, these layers being apparently composed of fine wavy-twining threads about $\frac{1}{2000}$ of an inch in diameter; but in section these threads are seen to be essentially circular tubes. The more exact measurement of these tubules is, according to Dr. M. C. White, outside measure $\frac{1}{1450}$ inch, the inner diameter, clear space, $\frac{1}{2200}$ inch. The outer portions of the layers seem more compact, and on weathering the fossil assumes a Stromatoporoid appearance. The form is accompanied by grains having in many cases a concentric structure, and these are apparently oölitic; yet with these are mingled minute fragments having the structure of the larger nematoid mass. These grains, oölitic, fragmental, and possibly in many cases the young of the animal, have in some instances penetrated the larger mass and partake with it the concentric arrangement.

In seeking the relationship of this fossil, its general character shows it to be allied to the sponges. The scanty materials at hand with which to make comparison do not permit me to pronounce with entire confidence as to its very nearest allies.

Sections of a fossil form, described by S. A. Miller, as *Stromatocerium Richmondense*, Journal of the Cincinnati Society of Natural History, vol. v, April, 1882, show here and there, but rarely, a structure which is probably identical. The newly

named Calciferous fossil, *Cryptozoön proliferum*, figured and described by Professor James Hall, Thirty-sixth Report of the Regents of the New York State University, helps to determine the relationship. A portion of that description reads: "The substance between the concentric lines, in well-preserved specimens, is traversed by numerous minute irregular canaliculi which branch and anastomose without regularity."

1



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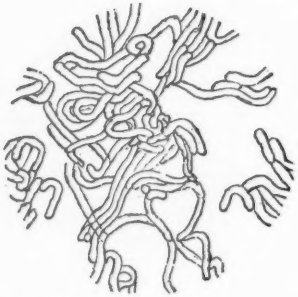


DESCRIPTION OF FIGURES.

1. *Strephochetus ocellatus* in rock, natural size.
2. The canaliculated structure of the fossil, enlarged one hundred diameters.
3. The same—view from near the center of the field, enlarged about three hundred and fifty diameters.

The sections made, and those viewed from the cuttings of others from what is supposed to be this Cryptozoön, do not show the described structure plainly enough to permit me to make satisfactory comparison with the Chazy form. The structure is possibly identical. The little canals which so largely make

up this little eye-like Chazy fossil go twining over and around each other, and up to the present time they have been rarely observed branching and never anastomozing.

This fossil does not seem near enough any already recognized form to be included in it generically, and until other relationships are found it may properly stand by itself a separate genus.

Strephochetus (στρέφω I twine, ὀχετός canal), nov. gen.

A free calcareous sponge showing in structure concentric layers composed of minute twining canals.

Strephochetus ocellatus, n. sp.

Type of genus. A compact calcareous sponge, spherical or slightly flattened, distinctly concentric in character, usually less than half an inch in diameter, forming when in masses, a tough limestone. When weathered the concentric character is very evident, the fossil then looking like little eyes peering from the stone.

These forms are often gathered in crowded masses, the intermediate spaces being filled with fragments of the fossil mingled with oölitic grains. More rarely they appear here and there in a mass of oölite.

This fossil occurs in connection with well recognized Chazy forms and especially with *Maclurea magna*. It is found in place in the towns of Addison, Bridport, etc., in Addison County, Vermont, and in bowlders in those towns as well as at Crown Point, N. Y.

Middlebury College.

ART. XLVII.—*William B. Rogers's Geology of the Virginias.** *A Review;* by J. L. and H. D. CAMPBELL.

MRS. WM. B. ROGERS could not have commemorated the life and labors of her distinguished husband in a more fitting way than she has done, by collecting and editing his reports and other valuable papers on the Geology of the Virginias, which form a neat and compact volume of about 800 pages. The geological survey of Virginia (at that time including West Virginia), for which Prof. Rogers, with a competent corps of assistants, was employed, was never fully completed; and yet enough had been done to justify his beginning work on his final report, while his assistants were closing up some remnants

* A reprint of Annual Reports and other Papers, on the Geology of the Virginias. By the late William Barton Rogers, LL.D., etc., Director of the Geological Survey of Virginia from 1835 to 1841; President of the National Academy of Sciences. New York: D. Appleton & Co.

of field work still to be done. In the last annual report which he was allowed to make (December, 1841), he says: "Having brought the active labors of the survey thus near their completion, I am now entering upon the task of preparing the final report. Those who, like the Board, have been able to follow me and my assistants in the diversified and laborious researches in which we have been actively engaged for nearly six years, and who reflect upon the immense extent of ground over which our explorations have been carried, the largest area ever submitted to systematic geological investigation in any part of the world, will be at once prepared to form a just idea of the number and extent of our results, and of the magnitude of the task of producing a full report on the geology of the State." (p. 543) The Hon. John Rutherford, at that time president of the Board of Public Works, in a communication to the Virginia Legislature, says: "To enable him, therefore, to present such a report, to arrange the numerous mineral specimens, and to prepare the necessary drawings and maps, Prof. Rogers recommends that the services of his corps, as at present organized, be continued until the close of the present geological year in April next, and that an additional appropriation of $2,500 be made for the purposes above mentioned."

Notwithstanding the cogent reasons given for making the needful appropriation, the Legislature of a great and then wealthy State, failed to grant the pitiful sum of $2,500 asked for in order to complete one of the most interesting and important geological surveys ever undertaken on the continent. Thus it happens that the fruits of nearly seven years of laborious research have been allowed to lie hidden from the public for more than 40 years—except in the form of a few obscure pamphlets—until within the last few months, when Mrs. Rogers has given them to the scientific world in a permanent form. If Prof. Rogers had been allowed to complete his work and reduce it to a systematic form, it would have been more satisfactory to the general reader than it is as now presented; and yet the volume before us is among the most valuable contributions made to our geological literature in a long time. It brings before the public for the first time a comprehensive view of a region, to which we wish to invite the attention of our fellow-laborers, as a *typical field* for geological studies.

With this end in view we propose to give a brief synopsis of what the field geologist will find here. We wish to show that the two Virginias embrace within their extensive area illustrations of every geological feature of the American continent, with the exceptions of the great "lava-flows" and the volcanoes of the far West, and the modern coral reefs of tropical seas. The excellent map and sections which accompany the volume,

illustrate our geology in a comprehensive way, and will be a most valuable help to a clear comprehension of the subject before us. But the younger field-workers at least, some of whom doubtless desire to see for themselves what we have in this wide and varied field of 61,400 square miles, will be aided in their explorations by brief sketches of some characteristic features of our several geological formations and a statement of points on leading routes of travel at which observations can be conveniently made. We therefore offer a general view of each of the geological formations and groups found in the Virginias, taken in their *chronological order*, which is not done in the volume; except so far as relates to a very concise view given of the several subdivisions of the Appalachian range in the second and third annual reports.

The notation by numbers from I to XVI, given by Prof. Rogers, will be retained in our present discussion as a part of the history of the survey, and at the same time we shall give the more complete and generally applicable notation of Prof. Dana's table, which has been practically adopted by Prof. Rogers in the last chapter of the volume, page 717.

It may be well to state in this connection that a brief summary of many of the most important facts given below will appear in our notes on Virginia prepared for a forthcoming new edition of Macfarlane's Geological Railway Guide.

The reader of Prof. Rogers's Reports will find some few mistakes and inconsistencies which no doubt would have been corrected had he lived to see his work pass through the press. But we must remember that he had to begin on a very wide and unexplored field, that he was laying an important part of the foundation of our grand system of American Geology, the superstructure of which has been in process of erection for half a century and more, and is not yet completed. In this preliminary work it is astonishing to find so few errors in the published results of his labors, and to find what a solid basis his successors have to build upon.

Archæan Group.—This group constitutes the country rocks over an extensive area in Virginia, but is found nowhere in West Virginia except in the N.E. corner near Harper's Ferry. To these rocks Prof. Rogers in his State Reports applies the old name, "Primary;" but in his notes for Macfarlane he adopts the term, "Archæan." His map shows very clearly the outline of this great geological belt, extending from the Potomac to the line of Tennessee. Its eastern boundary is a somewhat waving line extending from the city of Alexandria in a southern direction through the cities of Fredericksburg, Richmond and Petersburg, and cutting the line of North Carolina a little way north of Weldon. From that point its south

border is the Carolina line to its western limit. The "backbone" of the Blue Ridge marks out, with a few limited variations, its N.W. border from the Tennessee line to Harper's Ferry on the Potomac, a distance of about 340 miles. The narrowest part of the area thus defined borders on the Potomac between Alexandria and Harper's Ferry—about 50 miles by a right line. About one-third of this distance, however, is occupied by overlying beds of Mesozoic age, to be noticed hereafter in connection with a number of other large patches of the same age similarly situated.

In his State Reports, Prof. R. makes no subdivisions of his "Primary" formation, except of a very general lithological character; but in his notes for Macfarlane (note 6, p. 722), he indicates four subdivisions, and singularly puts their notation in the order, A, D, B, C. His D, which he calls, "Norian or Upper Laurentian," seems to appear on the railroads, according to his notes, at only two stations, one at the junction of the Chesapeake & Ohio with the Virginia Midland Railway, about one mile southwest of Charlottesville; the other seven miles farther in the same direction, at Ivy station on the Chesapeake & Ohio Railway. It is true that there are "four rather distinct groups of Archæan rocks found in Virginia, viewed lithologically," but we regard the question, as to whether or not they belong to so many distinct horizons, not sufficientiy settled to justify our recognizing more than the two general divisions, Laurentian and Huronian, 1*a*, and 1*b*.

One of the mistakes alluded to above, and which the reader will encounter early in his perusal of the volume, is found in two places in the Report on the "Geological Reconnoissance" of the State. On page 27 he says: "Observations render it doubtful whether in the Blue Ridge any truly primary rocks occur." Again on pp. 83, 84, in discussing "the region west of the limestones (below Lynchburg), as far as the western flank of the Blue Ridge"—that along his profile section No. I, which crosses the southern portion of Albemarle and northern corner of Nelson county—he comes to the "conclusion, that by far the largest portion of its surface is occupied by rocks which *do not* belong to the primary system, while they have, at the same time, served to display the modifying effects of igneous agents, as manifested in the changed structure of many of these rocks, on a scale of wonderful variety and extent. Early in the present report, allusion was made to the prevailing errors on the subject of the true geological character of this region, inclusive of the Blue Ridge; and enough has already been stated, in regard to the structure of the region, to satisfy the enlightened geologist of the entire impropriety of the designation, primary, which it has heretofore uniformly received."

In subsequent Reports, and in his notes on the geology of the Chesapeake & Ohio and Virginia Midland Railways he recognizes the rocks of this same region as primary or Archæan. We do not call attention to this change of view for the purpose of throwing any discredit upon the author's conclusions, but rather to indicate his honesty of opinion in changing where subsequent observations pointed out his error. In the subsequent Reports, made from more careful and detailed explorations, there is left but little room for such changes, while the general accuracy of his conclusions is remarkable for that early period.

Prof. Rogers's classification of the primary rocks is about as distinct as any that has yet been made, but the territorial limits given to these general classes, or rather their outcroppings, fall far short of covering the whole area occupied by them. Still he is correct as far as he goes in the following paragraphs; if his definitions are accepted.

"*Granite* (1*a*.)—An unstratified or igneous rock generally found inferior to or associated with the oldest stratified and metamorphic rocks, and sometimes penetrating them in the form of *veins*, and of *dykes* or *walls* rising in the midst of them. . . . A true unstratified granite, though extensively displayed in some parts of our southern district, is by no means of common occurrence. As an example of it I would cite the belt of whitish, hard, solid rock, extending from a little distance east of Little Falling River in Campbell county (S.E. corner), with a breadth of between one and two miles across Staunton River in the neighborhood of Brookneal," (pp. 287–88). Referring to exposures of gneiss and gneissoid granite near Richmond and Petersburg, he says: "We observe at many exposures, veins of granite and syenite penetrating the gneiss, and in some instances in such extent as to present large protruding masses, or broad surfaces of the granitic and syenitic rocks above, as may be well seen at several points along the James River canal (now the Richmond & Allegany railway), and perhaps still more readily at the rugged exposures adjoining the mills on both sides of the Appomattox at Petersburg," (p. 457.)

"*Gneiss* (1*a*.)—A stratified rock composed of the same material as granite, having a laminated texture. . . . Gneiss rocks are in extensive use as building material in nearly all of the Atlantic states. In the southern districts they have been quarried below Columbia and between that point and Lynchburg. . . . A wide belt of micaceous and feldspathic gneiss traverses Albemarle, Nelson, Amherst, Bedford, Franklin and Patrick counties, presenting frequent beds of granite and syenite, the latter more largely developed in proceeding toward the south-

west." (pp. 288–290). "Rocks of this description occupy a large portion of the district (northern). Besides being met with in intermediate lines, they are largely developed in two extensive tracts, one of which stretches in the form of a belt from the eastern flank of the Blue Ridge, to the neighborhood of Southwest Mountain in Albemarle county, gradually contracting in width in its prolongation toward the northeast, and finally near the Potomac, compressed between the flank of Short Hill and a line some distance west of the Kittoctin Mountains; the other forming an irregular triangular area, having its apex a little west of Fredericksburg, its eastern side in nearly a meridional direction, coinciding with the eastern limit of primary rocks along the head of tide, and its western side parallel to the general course of Southwest Mountain, and terminating a few miles west of Columbia. . . . Along the eastern margin and for some miles westward, the variety chiefly met with is a gray rock, consisting of quartz, feldspar and black mica with occasional spangles of white mica, and scattered grains of hornblende. It is of an even texture, readily separating into large slabs and blocks, suitable for columns and other purposes. . . . Of this variety innumerable exposures are presented on both sides of the James river in and above Richmond, and on the Appomattox in and above Petersburg, and a similar rock, though in much less extent, is seen on the Rappahannock above Fredericksburg." (pp. 455–456).

"*Micaceous, Talcose and Argillaceous Slates* (1*b*).—Westward of the triangular district of gneiss rocks just alluded to we find a broad belt of more slaty rocks, which, according to the peculiar ingredient predominant for the time, are either of the micaceous, talcose or argillaceous character. This belt reaches nearly to the eastern flank of Southwest Mountain, in Fluvanna, Albemarle and Orange counties; and farther north, though in part covered by the middle secondary rocks (Mesozoic), there widely expanded over the corresponding region, is still traceable in considerable width east of that formation through Fauquier, Prince William and Fairfax counties, as well as in narrow and interrupted tracts along the base of Bull Run and Kittoctin Mountains. . . .

"Referring however merely to general features, the micaceous composition, thus most strikingly exhibited toward the eastern margin of the slaty belt, is seen changing as we proceed west into one in which talc is more or less blended with the mica, and even in some places entirely displaces it. . . .

"Throughout the whole of this belt of slaty rocks, veins and beds of quartz are of very common occurrence, and, in the talcose and micaceous slates especially, are frequently more or less *auriferous*. In fact this belt includes nearly every locality

in the northern primary district in which mines have been opened for extracting gold, or in which the metal has been found; and it may be added, that its prolongation south of the James River embraces the gold district of that part of the State." (p. 459).

The gold belt of Virginia is of varying width, but nowhere probably less than several miles wide. It extends through portions of the counties of Spotsylvania, Orange, Louisa, Fluvanna, Goochland, Buckingham and Appomattox, in all of which counties gold has been mined to a greater or less extent for many years—in some places very profitably.

Associated with the slaty formations of this region is a remarkable belt of metamorphic limestone. It is comparatively narrow, but in length it has been traced almost entirely across the State in a northeast and southwest direction. It is crossed by the Chesapeake and Ohio Railway near Gordonsville, while the Richmond and Alleghany Railway follows it longitudinally with the valley of the James from near Howardsville in Albemarle county to the great bend below Lynchburg. Our present view is that this belt and the slates described above are *Huronian* (1*b*).

To those geologists who may wish to examine in person the Archæan group so widely developed in Virginia, we would suggest some convenient points for explorations near stations on the principal railway lines in this portion of the State—beginning in the northeastern part of the Archæan belt.

(1.) On the Washington and Ohio Railroad, near Falls Church, Vienna and Hunters, and between these stations, may be found exposures of some prominent members of the group in cuts and along the margins of streams.

(2.) Near the Richmond, Fredericksburg and Potomac Railroad, fine exposures of the gneisses and gneissoid granites are readily found in the quarries along the Rappahannoc above Fredericksburg; along the banks of the James at and above Richmond and along the Appomattox at Petersburg.

(3.) At Fairfax on the Virginia Midland Railway; near Charlottesville on the Rivanna River, and along the river cliffs at Lynchburg, are points favorable for inspection.

(4.) Of all the leading routes of travel in Virginia no one affords so many favorable localities as the Richmond and Alleghany Railway for the study of the different formations from the lowest beds of the Archæan up to the top of the Hamilton group of Devonian age. From Richmond to Scottsville this road, following the valley of the James, cuts the ledges nearly at right angles to their strike. For several miles above Richmond the gneisses and granites are exposed to view in quarries and cuts. Then, after crossing the Richmond coal-fields, good

exposures are found near Goochland C. H. of beds of gneiss and slates; and at Columbia quarries of gneissoid granites are worked, and several gold mines are not far north of the same point. Bremo Bluff, a few miles farther up the river, presents some good points in the great gold-bearing slate belt. This is the best point of departure for visiting Buckingham, one of the most interesting mineral counties in the State. A few miles west of Scottsville in Albemarle county, the line enters the limestone belt described above, and changes its course toward the southwest. The river has cut a serpentine channel of considerable depth in the general direction of the strike of this belt and exposed the limestones and their associated rocks to view at numerous points for a distance of about fifty miles. Among these points we may mention the vicinities of New Market, Gladstone, Walker's Ford and Stapleton.

The Richmond and Alleghany Railway from Lynchburg to Rope Ferry bridge cuts the Archæan beds nearly at right angles to their strike, and affords well-defined exposures at or near every station. About a mile and a half below the bridge on the north side of the river, the contact of the Archæan rocks (1*a*) with a trough of Cambrian age overlying them may be readily observed.

The Norfolk and Western and the Richmond and Danville railroads both afford some favorable points for observation in this ancient group; especially near Burkesville at the intersection of these lines, and at Lynchburg and Liberty on the former, and near Amelia C. H., Boston and Danville on the latter line.

Cambrian, Primordial (No. I, Rogers), or Potsdam, 2*a*, *b*.—Virginia affords rare facilities for studying this group, except the Acadian epoch, 2*a*, the existence of which along this portion of the Blue Ridge range has not been ascertained with any certainty. If it be here it is not characterized by fossil remains. Professor Rogers thus describes the rocks of this group: "The rock, or group of rocks, which is frequently exhibited in extensive exposures along the western side and base of the Blue Ridge, more especially in the middle counties of the valley, is usually a compact, rather fine-grained, white or yellowish gray sandstone, where resting on the declivity of the ridge, it presents a gentle inclination to the northwest—while the subjacent and more ancient strata of the ridge, in almost every instance, dip steeply to the southeast. In Page, Rockingham, Augusta, Rockbridge (and Botetourt) counties this group forms the irregular and broken range of hills lying immediately at the foot of the main Blue Ridge, and sometimes attaining an altitude little inferior to that of the main mountain. A level region, sometimes of considerable breadth, and strewed

profusely with fragments of this rock, in general intervenes between the rugged hills and the first exposures of the valley limestones. . . . . In many instances two, sometimes three, ranges of hills are interposed between the limestones and what may be considered the termination of the rocks of the Blue Ridge." Of the higher beds of these sandstones—the more purely siliceous—he says: "In nearly all the exposures from Balcony Falls (in Rockbridge county) to Thornton's Gap (in Page county) as well as at various other places it exhibits vague fucoidal and zoöphytic impressions on the surfaces of bedding, together with innumerable markings at right-angles to the stratification, penetrating in straight lines to great depths in the rock, and from their frequency and parallelism determining its cleavage in nearly vertical planes. These markings are of a flattened cylindrical form, from $\frac{1}{4}$th to $\frac{1}{10}$th of an inch broad, giving the surface of the fractured rock a ribbed appearance, and resembling perforations made in sand which have been subsequently filled up, without destroying the distinctness of the original impressions" (pp. 167, 168). This is his account of the *Scolithus linearis.*

"At Harper's Ferry and for some distance south, where the altered character of the sandstones and slates of this formation renders it occasionally difficult to recognize the true dip, and even to identify the rock itself, an eastern declination is almost uniformly observed, the slates forming a portion of the bed of the Shenandoah, dipping beneath the sandstone which rises in bold cliffs along its eastern margin, while the limestone of formation II (3*a*, *b*), dips in the same direction beneath the slate, thus pointing to an inversion extending entirely through formation I, and even affecting to a great distance the rocks of formation II . . . . At Balcony Falls, where the western dips are preserved throughout a large part of the thickness of this formation, the most favorable opportunities are presented for studying the composition and marking the arrangement of these rocks. The formation here rests upon igneous rocks, chiefly of the syenitic character, which in this place form the main axis of the Blue Ridge. These are well seen in traveling along the tow path of the canal (now the R. & A. Railway) which follows the course of the river through the wild and beautiful gorge by which it makes its way from the valley eastward. As we approach the western termination of the pass, we mark the commencement of the rocks of formation I, which are seen on the side of the canal (railroad) lying on the syenitic mass with a northwest dip. The lowest stratum, or that in contact with the syenite, is a brownish decomposing slate, evidently much altered by its proximity to the igneous rock beneath; next is grayish and reddish sandstone; then a slate similar to

the former, then a repetition of the sandstone, again a slate, and at the termination of the gap heavy beds of massive white sandstone, such as constitute the type of this formation. The average dip of the latter, as presented in the imposing cliffs which guard the entrance to the pass, is 55° N.W." (p. 205). The above account given by Prof. Rogers does not coincide entirely with the geology of this same mountain gorge, as presented in a paper published in this Journal, vol. xxix, June, 1885. The difference however, so far as regards the portion west of the axis of the Blue Ridge, is not in the general features but simply in the more *detailed* account given in the Journal. But as to what is east of the axis the case is quite different. We have fully ascertained as a settled fact that the beds of sandstones, conglomerates and slates for fully two miles east of the main mountain are of Cambrian age, forming a comparatively shallow syncline resting on Archæan rocks which are exposed along both of its margins, as shown in the paper referred to above. We have recently ascertained that this area cut off from the principal mass of the Cambrian beds, and thrown over to the eastern base of the mountain, extends at least ten miles northeast of James river towards the head waters of Pedlar river in Amherst county.

Some months before this volume of Rogers's Reports came into our hands, we examined another area on the east side of Blue Ridge at Tye River Gap in Nelson county, which is covered with alternating beds of conglomerates, slates and sandstones, considerably metamorphosed but bearing a striking resemblance to the *lower* Cambrian beds east of the mountain at Balcony Falls, which we suspected were of the same age. The only circumstance militating against that conclusion, was the absence of Scolithus borings in the sandstones. But this may be accounted for by the fact that these remains are rarely if ever found in the lowest beds in this region, and the additional fact that higher beds seem to have been swept away. More extended and minute research in this region may, however, yet prove the presence of Scolithus borings. In describing a section of rocks cropping out at Tye river Gap, Prof. Rogers says: "There are also noticed two bands of sandstone and slate. That on the western side occurs about one mile below the summit, is about 200 yards in width, and consists of gray and reddish slates, sometimes micaceous, with associated layers of sandstone, conglomerate, greenstone and greenstone slate. The greenstone is sometimes amygdaloidal.

These layers are horizontal, and with a moderate dip to the S.E. The other band occurs about ½ mile below the summit on the *east side*, and presents repeated alternations of red and gray slates, white sandstones and conglomerates. They are

nearly vertical with a high dip to the S.E., and in width extend half a mile" (p. 313).

The foregoing would serve well as an accurate description of the lower beds of Cambrian age at several points we have observed along the Blue Ridge, with perhaps the exception of the amygdaloidal greenstone; but these beds, at least those on the east side of the mountain, are nowhere in the Reports referred to his formation I. Though on section No. 9, accompanying the published volume, we are pleased to find our suspicions verified, so far as the coloring of the section indicates Prof. Rogers's conclusions—arrived at no doubt from his latest revision of his earlier work. There is at least a probability of other portions of the eastern margin of the Cambrian rocks being cut off from their main mass by the elevation of the core of the Blue Ridge. At any rate, enough has been definitely determined to prove that the axis of this mountain does not everywhere mark out the eastern coast line of the great Paleozoic ocean, and that it will be worth our while to search for shore marks farther east than has been our custom heretofore.

Points convenient for studying the Cambrian group in Virginia have been incidentally mentioned already, and nothing more is called for under this head than a summing up of such localities as are readily accessible from railway stations. At Harper's Ferry, Prof. Rogers's section No. I appears to make the main mountain and the Short Hill some distance east of it, both Cambrian, with an uplift of Archæan beds between them. In his notes in Macfarlane's Guide he calls the rocks here, "Altered Cambrian 2*b*, or Archæan B, followed west by Cambrian 2*b*, 3*a*." Prof. Fontaine, in his notes for Macfarlane on the Baltimore & Ohio railroad, says: "The gorge at Harper's Ferry is cut through metamorphic rocks, of probably Huronian age. One-and-a-half miles west of the station, a fault brings down the Potsdam and Calciferous rocks against the Azoic." This is an interesting point, and worthy of further investigation. It seems to present another example of a belt of Cambrian rocks thrown to the eastern side of the Blue Ridge axis. We have not studied this portion of the formation with sufficient care to form a definite opinion of its peculiarities of structure.

The Manassas Gap railroad cuts the beds of this age between Happy Creek and Front Royal. The same formation is again well exposed at Thornton's Gap, a few miles east of Luray on the Shenandoah Valley railroad. There are numerous points on the same line from which good exposures of 2*a*, *b*, may be conveniently reached, as the road skirts the margin of the formation from Front Royal to Roanoke, a distance of 177 miles. Such points as Milnes, Crimora (near Turk's Gap),

Waynesboro, Vesuvius, Loch Laird and Buchanan, are worthy of note. Then Balcony Falls, already mentioned, and Buford's on the Norfolk & Western railway in Bedford county.

VALLEY LIMESTONES—No. II (*Canadian*, 3*a*, *b*, *c*).—Under this division Prof. Rogers in his State Reports embraces what is now recognized as the Canadian group (3*a*, *b*, *c*), and the Trenton Limestone (4*a*). But in his notes, prepared for Macfarlane's Guide, he gives the latter its true place. We know of no region in this country which offers a more extensive or better defined display of this important geological group than the "Great Valley of Virginia." This valley occupies a belt extending from the Potomac on the N.E. to the line of Tennessee on the S.W., a distance of about 340 miles, with a breadth varying from 15 to 25 miles, giving an area not much if any less than 6,000 square miles. We here quote Prof. Rogers. "The extensive zone comprehended under this title embraces all that portion of the State having for its eastern boundary the western slope of the Blue Ridge and its inflected continuation the Poplar Camp and Iron Mountains, and for its western, the Little North, and a portion of Big North Mountain, with the southern portion of the former, Caldwell's and Brushy Mountains; and, near its southwestern termination, . . . the extension of Walker's Mountain" (p. 203). . . . "From the Potomac southward nearly to the Rockbridge line, it presents the forms of two belts, separated by an intervening tract of variable width, formed of the next or several of the next superior formations. As far south as the northern termination of Massanutten range, the dividing band is composed exclusively of the group of slaty rocks constituting formation III, (4*b*, *c*). Farther south these mountains bear aloft still higher formations, resting upon a basis of the slates, and broadly skirted by them on either side; and again, after the termination of these ridges in the peak near Keezletown, the same zone of slate continues its course toward the south, gradually diminishing in breadth until it eventually disappears. Similar interruptions in the continuity of the limestone rocks are produced by the Short's Hill, Purgatory and other mountains toward the S.W. portions of the valley. . . . . The prevailing dip of the limestone along its eastern margin, where it joins the shales of formation I, is to the southeast. Indeed but few instances occur in the State in which this rock is seen reposing in its natural position upon these older strata. As might be inferred from the general prevalence of this inversion in the vicinity of the Blue Ridge, the natural causes by which it was brought about exerted a powerful influence upon the position of all the rocks of the valley, and in some instances would seem to have propagated a like inversion entirely across this zone and even

into the rocks composing the mountains bounding it on the west." (pp. 209, 210).

Prof. Rogers nowhere in his State Reports undertakes to subdivide these limestones by the several horizons which he gives them in his notes for Macfarlane's Guide (see pp. 717, 720). Here he recognizes the three subdivisions, 3*a*, 3*b* and 3*c*, which are tolerably well defined in the Great Valley.

We are aware that Prof. Dana in his "Table of Formations," as revised for Macfarlane's Geological Railway Guide, has reduced the sub-divisions of the Canadian group to two, Calciferous and Chazy, for which we have no doubt he can present very cogent reasons. In the Virginias this whole group is more remarkable for the paucity than for the abundance of its fossils; but still enough have been found to mark its place in geological history. Under the guidance, however, of organic remains alone, we have not been able to trace very definite horizons for separate epochs in this Canadian period, but when we call in the aid of lithological features as an additional basis of division, we find *three* tolerably well defined formations, blending into one another to some extent it is true, but not more so than is very common in contiguous and conformable limestone beds.

It is a fact worthy of note that what we call three formations of this period carry with them, throughout their whole extent of 340 miles, such well defined lithological peculiarities as to indicate clearly that they were severally deposited under quite different, though not suddenly changed, circumstances.

The lowest beds, which we regard as corresponding with the Calciferous (3*a*) of New York—though containing here far less of calciferous sandstone than of calciferous shale—is well characterized, as exposed in numerous ravines along the western base of the Blue Ridge, by heavy beds of purplish shales, with interstratified beds of dolomitic and siliceous limestones, like that employed at Balcony Falls factory for making hydraulic cement. The shales are both calcareous and ferruginous, but become more calcareous and less ferruginous as they are found to rise higher in the series.

In our notes on the Virginia railroads, prepared for a new edition of Macfarlane's Geological Railway Guide, we have retained the Quebec (Levis) (3*b*) as a distinct division because of the comparatively abrupt transition from predominating ferruginous shales on the one hand, to predominating ferruginous and dolomitic limestones on the other, on the surfaces of which we find in some localities numerous fucoidal impressions quite different from any found in the lower series. Here the limestone beds increase in thickness, in the regularity of their bedding, in their purity as regards silica and alumina, but they carry iron enough to produce by their disintegration dark, fer-

tile soils. At many points, as may be seen between Charlestown and Luray on the Shenandoah Valley Railway, the interbedded shales become very much thickened at the expense of the limestones, but the general lithological peculiarities are well preserved at nearly all exposures of the beds along the Great Valley. Many of the limestones of this division are hydraulic, as at Shepherdstown on the Potomac, and on North River, six miles south of Lexington, at both of which points cement has been manufactured.

The transition from 3*b* to the upper division, (Chazy 3*c*), is not very sharply defined, yet we feel assured, in passing from the outcroppings of the lower beds to those of the higher, that we have come upon strata deposited under a decided change of circumstances. The beds consist of a larger percentage of carbonate of lime, but are less regularly stratified, and have fewer interstratified shales; a comparatively thin bed of brown sandstone full of impressions of fossil shells imperfectly preserved, appears among the lower beds, and is very continuous; then higher up and not far below the base of the Trenton limestone beds of chert of variable thickness are found—sometimes a single bed but often two or three. "In some of these slaty bands, and in the cherty beds so largely interstratified with the limestones of the valley, Goniatites, Ammonites and other remains are by no means infrequent, and when found are generally in a beautiful state of preservation." (p. 172).

THE TRENTON GROUP—No. III of *Rogers*, (4*a*, *b*, *c*).—[*Trenton Limestone* was included among the "Valley Limestones" in the State Reports, but on p. 717 it is put in its true place]. Both the upper and the lower horizons of this group seem to be well defined throughout its whole extent in Virginia. The lower division, Trenton limestone (4*a*), in many places abounds in corals (Chætetes, Columnaria, etc.), while all the classes of Mollusca (Brachiopods, Lamellibranchs, Gasteropods and Cephalopods), have numerous representatives—often in great abundance. In the counties of Augusta, Rockbridge and Botetourt, the lowest beds of Trenton are evidently composed of the debris of an ancient coral reef with some admixture of mollusks and crinoids all cemented by infiltration of carbonate of lime into a solid limestone from 100 to 200 feet thick, of a fine gray color and highly valued for architectural purposes.

Between the Trenton limestones and the Utica shales (4*b*), there is no well defined plane of separation. The transition is manifested by a rapid diminution in the number and thickness of the fossiliferous limestones, and a corresponding increase of shales, until shales alone constitute the upper portion of the formation. The transition to the highest division, 4*c*, in the middle counties of the State is marked by changes in both

lithological and paleontological features. The shales become more ferruginous as well as more siliceous. In fact some of the highest beds become really argillaceous sandstone of a purplish color with thin layers of similarly colored shales intervening. This part of the formation is in many portions of its range the repository of valuable ores of iron.

Prof. Rogers gives a very good view of some of the leading exposures of his No. III (4*b*, *c*.) "This member of the series consists of slates and slaty sandstones, of various shades of bluish black, lead color and yellowish brown, the dark varieties in general predominating. Their structure is laminated and fissile, not unfrequently evincing the presence of small quantities of mica. When weathered they in most cases assume a yellowish or dingy brown appearance. Usually this slate is devoid of carbonate of lime, though bands are occasionally met with containing organic impressions, and of a composition more or less calcareous. Iron pyrites is of very common occurrence, giving origin to the sulphurous impregnation of numerous medicinal springs taking their rise in these rocks. . . .

"Resting immediately upon the upper boundary of valley limestone, No. II (3*c*) this rock or group of strata is exhibited on a very extensive scale along the base and flanks of the Peaked Mountains and the Massanutten, and other parallel ranges in Shenandoah, Rockingham, Page and other counties. From the synclinal structure of most of these ridges, the slate is exposed on both sides of the mountain, dipping inward, that is, to the N.W. on the eastern side and S.E. on the western side. The striking symmetry of contour exhibited by the Peaked Mountains [southwest terminus of the Massanuttens], when viewed endwise from a point south of the termination of the range, illustrates the basin-shaped arrangement of the strata of slate resting in a trough of subjacent limestone, and surmounted by the sandstone which forms No. IV (5*a*) of our series. There are few, perhaps no other, exposures in the slate in which the structure and relations of these beds can be so satisfactorily observed, as in the group of mountains here referred to. . . . " (p. 174).

"It has been seen that this formation, constituting a broad belt extending from the Potomac far into the middle counties of the valley, constitutes a great synclinal trough, the northern portion of which stretches far into Maryland, sustaining for a considerable part of its length in Virginia, the group of long parallel ranges called the Massanutten Mountains. . . . Under like circumstances this formation is found constituting the trough-shaped basis on which the higher formations repose in the House Mountains, Short's Hill and Purgatory Mountains. In the House Mountains, the slate forming the base and extend-

ing about two-thirds of the height presents but gentle dips, so that the two successive formations III and IV (*4b*, *c* and *5a*), of which they are composed, are piled upon the subjacent limestones in nearly horizontal planes." (p. 218).

"On the western margin of the valley a narrow belt of formation III extends from the Potomac along the base of Little North Mountain, to its termination in Rockbridge county. It then bends westward a little south of the gap through which flows the North River, and again resuming its course parallel to the Blue Ridge, spreads along the flanks of the main North Mountain and its continuations; . . . keeping this direction it skirts Caldwell's Mountain, and continues low down on the North or Brushy Mountain, to its termination in Washington county" [on the Tennessee line]. (p. 219).

In the Appalachians of the Virginias are some very interesting, and some of them quite extensive and fertile anticlinal valleys, of which the Canadian and Trenton limestones form the bottoms, while the Utica and Hudson slates constitute the lower slopes and spurs of the ridges by which the valleys are bounded. Such are the Crab Bottom in Pendleton and Highland counties, Warm Springs Valley in Bath county, Rich Patch in Alleghany, Sweet Springs Valley in Alleghany and Monroe, and Sinking Creek Valley in Craig and Giles counties.

The formations of the Canadian and Trenton periods are so frequently accessible to traveling geologists from the same points on railway lines and places of common resort, that we have concluded to note such localities under one general head. In the northeast portion of the Great Valley, the main stem of the Baltimore & Ohio Railway cuts the broad Silurian belt nearly at right angles. About one or two miles west of Harper's Ferry station the road passes rather abruptly from older beds to the Canadian limestones and shales, which are exposed in several cuts between that point and Kearneysville. Still farther west the more fossil limestones and shales of *4a*, *b*, *c*, come into view as far as Martinsburg and beyond.

The Valley Branch of the Baltimore & Ohio railway runs for a short distance from Harper's Ferry on the west border of the Cambrian, but soon passes to the Canadian, group which may be conveniently observed at Charlestown and Cameron stations. At Wadesville, and along the banks of Opequon Creek above and below, the exposed rocks are of Trenton age—a part of the irregular synclinal belt which 25 miles farther towards the S.W. passes beneath the Massanutten range. Winchester, Woodstock, Harrisonburg, and Staunton are all near the western margin of the Trenton belt of the Massanutten range, and afford conveniently accessible

outcroppings of 3*b*, *c*, and 4*a*, *b*. After passing Staunton this line cuts 3*b* and *c*, for five miles, then runs for a few miles on 4*a*; then before reaching Greenville it again runs upon 3*b*, *c*, which are well exposed in cuts and along streams to a point within six miles of Lexington, where 4*a* becomes the country rock and so continues to be until we reach the town, which is built upon Trenton limestone. The river cliffs for five miles above and below the railway bridge at this place, together with the hills surrounding the town, and the flanks of the neighboring House Mountains, afford unsurpassed facilities for studying both the Canadian and Trenton groups, and especially the latter.

The Manassas Gap railway, between Front Royal in Warren county and Strasburg in Shenandoah county, crosses the trough in which the Massanuttens rest at the extreme northeast terminus of that range of mountains, affording not only views of the Trenton foundation, but also of the superstructure of Medina and Clinton sandstones which form the crest of the historic Fort Mountain.

The Shenandoah Valley railway starts upon 4*a*, at Hagerstown, Md., crosses the Potomac on a bridge, the abutments of which are 3*b*. From this point to its terminus at Roanoke City, in Roanoke county, Va., its bed is composed almost entirely of Canadian, with a few patches of Cambrian and considerable areas of local drift. The road at some points affords opportunities for interesting observations. The cliffs of the Potomac at Shepherdstown, the cuts near Charlestown and the margins of both branches of the Shenandoah near Front Royal, bring into view well-defined beds of 3*b*, *c*. At Luray, the station and the greater part of the village appear to rest upon 3*b*, while the entrance to the caverns is, as far as we have been able to examine the locality, most probably in a hill composed of 3*c* (Chazy). Weyer's Cave, in the eastern corner of Augusta county, has about the same geological features and surroundings as the Luray caverns. Waynesboro is close to the line of connection between the Cambrian and the Canadian groups, and is a favorable point at which to study the structures of both, while the neighboring tunnel through the Blue Ridge shows the relation of the Archæan and Cambrian rocks with their actual contact at the western extremity of the tunnel, where apparent conformity exists between the two series. The Natural Bridge and the cliffs about Buchanan are both favorable localities for examining beds of 3*a*, 3*b*, and 3*c*—all being well exposed in the vicinity.

From Balcony Falls to Eagle Rock, in Botetourt county, the Richmond and Alleghany railway crosses the strike of the valley limestones in such a way as to open some well-defined sections.

But along the Lexington branch of the same road, the beds from the Cambrian to the Trenton are cut by the road and the river (the channel of which it follows) in such a way as to expose in a striking manner the numerous faultings and foldings to which this portion of the Great Valley has been subjected at some remote period of its history. A profile section from the crest of the Blue Ridge through Lexington and cutting the House Mountains, may be seen in this Journal, vol. xviii, 1879, p. 19. It is designed to show in a graphic way a variety of structures not often found within the same compass.

Our sketch has now brought us to the top of what is generally regarded as the Lower Silurian Age. We have dwelt upon this portion of the geology of Virginia at some length; first, because the formations of which we have been treating are remarkably well and widely developed in this State; and secondly, because we desire to give our fellow-students the benefit of a concise, and, as far as space and time will permit, a systematic view of the field which is still open for additional investigations. The higher formations we shall discuss hereafter.

Washington and Lee University, Va., September, 1885.

[To be continued.]

ART. XLVIII.—*On displacement through intrusion;* by JAMES D. DANA.

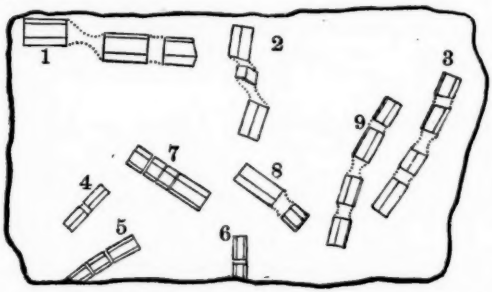
THE wedging action of intruding material may act either in fissures and crevices, or among the grains or constituent particles at or near the surface of a rock; and the displacement that results may consist in the opening and widening of fissures, in the separation of masses, in the faulting of the separated fragments, and in rock disintegration. The methods are either organic, molar or molecular. The *first* includes, (1) the intrusion of vegetable growths from microscopic plants to the roots and stems of trees; the *second* (2) the intrusion of melted rock into fissures or between layers; (3) the intrusion of gas under pressure, or when suddenly developed; and the *third* comprises (4) the freezing of intruded water, (5) chemical deposition from a solution of outside origin; (6) chemical deposition or composition, arising from changes within the rock. The minutest grain of a new mineral made or deposited within the rock has a displacing and disruptive action or tendency.

The production of a pseudo-breccia from quartzyte, described by me in this Journal for last November and January (xxviii, 451, xxix, 57), is an example of displacement by one of the

last two methods here mentioned; that is, through deposition from either an introduced solution or from oxidation of inside pyrite (or other iron-bearing mineral). A specimen of this pseudo-breccia, from Canaan, Conn., nearly three inches each way, recently shown me by Mr. R. E. Cornish, of Norfolk, Ct., consisted on one side of small angular blocks of the quartzyte, irregularly displaced, and having the large interstices lined and partly filled with limonite; while on the opposite side, the quartzyte was solid excepting a few fine rifts occupied by limonite. The limonite in the specimen was so abundant that it must have been derived from an outside source, and the mass of quartzyte probably came from the gravel of a limonite deposit or some place where limonite-making was going forward. Under such a condition, the deposition of a coating of crystallized quartz over the limonite might come from the silica which is set free (and abundantly so) in the decomposition of the schist adjoining the limonite-making locality.

The interstices between the pieces of quartzyte are, as stated above, only *partly* filled; and hence open cavities are left. This condition results because the separation, even though wide, requires that the deposited mineral should cross the interstitial space only at one or two points; and when the limonite deposit in the cavities is a smooth coating, or botryoidal, or covered with drusy quartz, the cavity has become a small geode.

The specimen figured below exemplifies a somewhat different case of displacement by intrusion, coming under the 5th of the above mentioned methods, which is essentially the same with that of the pseudo-breccia in the method of applying the



divellent force. It is a piece of well-characterized mica schist of the muscovite variety, containing broken and displaced crystals of black tourmaline. It was obtained on one of my Berkshire excursions of last summer from a quartzyte ridge up Roaring Brook, on the eastern border of the town of Lenox.

The broken prisms of tourmaline are various in amount of

displacement, the largest interval being about a third of an inch. Some of the displaced pieces are partially revolved, and some are tipped out of the plane of the rest of the crystal. The intruded mineral is quartz, a milk-white variety; and its form between the tourmaline fragments is shown by the dotted lines.

The displacement is evidently not wholly due to any compression of the rock, or to movement within it in any direction as a result of pressure or tension—the usual explanation in similar cases (and probable causes of fracturing); for the prisms of tourmaline lie, and are displaced, in all directions, and those that are side by side differ greatly in amount and kind of displacement as well as in its direction. The displacing agent was silica from an intruding siliceous solution; and deposition of quartz from the solution must have been continued at the plane of junction with the tourmaline until the displacements were completed. The change of direction and partial rotation of some of the tourmaline sections are evidence of irregular resistance to the displacement in the material of the rock.

In my note, on the "Decay of Quartzyte," in the number of this Journal for last January (xxix, 57), I refer to the "split and enlarged heads and stems of crinoids" as examples of the separation process. Being aware that crinoidal specimens of this kind had received much attention from Professor A. H. Worthen, Director of the Illinois Geological Survey, I wrote him recently on the subject, and here introduce his valuable letter of October 8th, received in reply.

"In reply to yours of the 5th inst., I will say that I know of no general report on the geodized fossils of the Keokuk limestone. At the St. Louis meeting of the Amer. Assoc., in 1878, I read a short paper on this subject, and exhibited specimens both of crinoids and shells that had been subjected to the geodizing process. No copy however was furnished for publication. I have seen one specimen of a geodized stem of Barycrinus nearly or quite a foot in diameter and have specimens in my own possession from four to six inches in diameter. Where shells have been geodized their size is not usually increased so much, and I do not now call to mind any specimen where the diameter has been increased more than half its original size. The stems of Barycrinus have a pentangular central perforation which seems to render them peculiarly susceptible to this process. The stems of large specimens of Barycrinus vary from one to two inches in diameter, and increase by the geodizing process from four to six diameters."

The process here described is of wide geological importance. As the cases show, any intruding mineral may act like the quartz and limonite, in the disrupting, and displacing work. The limit of the width of separation that may thus be occasioned remains to be ascertained from further observations.

ART. XLIX.—*An Endoparasite of Noteus;* by SARA GWENDOLEN FOULKE.

IN classifying the *Ciliata-Holotricha*, W. Saville Kent has created a special division for those members of the order which possess no distinct oral aperture, distinguishing them as the *Holotricha-Astomata*. This division includes but one family group—the Opalinidæ—comprising four genera: *Opalina*, *Anoplophrya*, *Haptophrya*, and *Hoplitophrya*. The Opalinidæ are, without exception, endoparasitic in habit.

Of these four genera the characteristics may be summed up as follows: *Opalina* and *Anoplophrya* are both free swimming, without means of attachment, and differ chiefly in the form of their endoplast; *Haptophrya* and *Hoplitophrya* are both furnished with means of attachment, the difference in form of which furnishes the generic distinction, the former possessing a sucking disc, the latter a corneous keel-like band, or one or more hooks. *Opalina* proper is further separated by restricting its habitat to "the intestinal viscera of various tailed or tailless Amphibia."

A *Noteus*, species unknown, having been crushed in the live-box, there were expelled from the animal's body, with its fluids, ciliated bodies exhibiting decided movements. Scarcely more tangible in their colorless transparency than air-bubbles, these bodies, varying in shape from globose to ovate, were more or less uniformly clothed with long, delicate cilia, whose rhythmical undulations produced but slight onward motion. No endoplasm was visible, and no opportunity for the use of reagents was afforded, as, in about ten minutes, the bodies became quiescent, and then rapidly disintegrated, the cilia disappearing first. Dr. Jos. Leidy recommends as a successful medium of preservation for such forms a little white of egg introduced into the water, which is not of itself sufficiently dense to support so delicate cell-walls.

One of the forms was gourd-shaped, the constriction being slightly above the middle, the whole appearance strongly suggesting lateral fission. Another, perfectly globose individual contained a number of the refractive germ-like bodies characteristic of the Protozoa, which, on being liberated by the dissolution of the parent cell, dispersed through the water, probably to seek a new host and complete the cycle of development. On the globular form the cilia appeared to be placed in bands or clusters, while those on the ovate form were more evenly distributed. It is possible that one may be merely an immature form of the other.

Simultaneously with these parasites a sac of protoplasm, measuring only $\frac{1}{1000}''$, and containing ten minute, scarlet to dark red bodies, was expelled. It seemed to come from near the center of the forward part of the body, but was not connected with the "eyes," as these remained intact. This sac remained motionless near the Rotifer for an hour, the scarlet bodies continuing in incessant motion during that time, but no change of any kind taking place. I have been unable to determine the nature of this sac or the contained bodies, and should be glad of any information as to its probable character.

The parasites measured about $\frac{1}{600}''$, exclusive of the cilia, whose length more than equalled the diameter of the body. I believe them to have come from some one of those cavities of the Rotifer's body which are filled with clear, rather thin fluid, perhaps from the stomach, but think it unlikely they can have come from the intestinal canal, because of their extreme fragility, and of the very long investing cilia, making the total size too great for such confined quarters.

The characteristics above noted bring this form within the genus *Anoplophrya*, if we except the inconspicuousness of the endoplasm, supposing it present, but prevent its identification with any specific form there included, that to which it most nearly approaches being *A. socialis*, described by Dr. Leidy, under the name of *Leucophrys socialis*, as present in the fresh-water Polyzoon, *Urnatella gracilis*. From *A. socialis* it differs, however, in point of size, being but one-sixth that of the latter; in not having the cuticle striate, and in the superior length of its cilia.

I propose to name this new species *Anoplophrya Notei*.

Briefly stated, the specific characteristics of this form are as follows: body globose or ovate, variably clothed with cilia more than equalling its length; endoplast undetected; contractile vesicle small; length, $\frac{1}{600}''$. Hab., endoparasitic of *Noteus*.

ART. L.—*The Spectrum of Nova Andromedæ;* by O. T. SHERMAN.

WHEN the telegram announcing the outburst in the nebula of Andromeda arrived, the equatorial of the Yale Observatory was in use following the spectra of γ Cassiopeiæ and β Lyræ. For some time past the astronomer had been engaged upon them and was beginning to feel sufficient confidence to commence the record. This practice is of more than apparent importance as it underlies the whole work with the nebula. As

precaution in observing, the eye was used only after some hours sleep, the spectrum was gazed at intently for some moments and subjected to a slight apparent to-and-fro motion. No light more brilliant than the first glare of a match was used. The spectroscope was a direct vision by Duboscq, provided with two series of prisms. Using the single series, b_3 and b_4 are just separated, using the double series the nickel line between the D_1 and D_2 and the fine lines between b_1 and b_2 are visible. The single series was usually employed for work, the double as a check.

On the earliest opportunity after receiving the information, namely the early morning of September 5th, the telescope was directed to the Nova. On the whitish blue stripe forming the continuous spectrum were discerned one bright line crossing the spectrum and farther toward the red two bright knots of light. They were not very much brighter than the surrounding glare but were evident. They remained when the larger dispersion was employed.

Settings were made by bringing the cross wire appearing as a dark line upon the bright background over the apparent condensation. The scale was read by the glare of a match and the observation recorded by a pencil dot upon a prepared form. The instrument was then pointed to the comparison star, say γ Cassiopeiæ and a similar observation made. This process was repeated independently upon Sept. 5, 7, 9, 11. On Sept. 16 and 21 the lines were seen but no setting attempted. Since then no observations upon the Nova have been obtained. The mean of the settings upon the three stars gives the following series:

	γ Cass.	β Lyræ.	Nova Androm.
$H\alpha$	20°·2	20°·32	
D_3	19·35	19·44	
?	19·10	19·03	18·98
?	18·5	18·43	18·51
$H\beta$	17·56	17·51	17·55
$H\delta$	15·93	15·90	
$H\gamma$?	14·20	14·25	

The lines $H\alpha$ D_3 $H\beta$ $H\delta$ have been identified by other observers. On their foundation the curve connecting the scale readings and wave lengths was drawn. The equivalents of the scale readings read off are:

From γ Cass.	From β Lyræ.	Mean.
18·51 = 536·0	527·0	531·5
18·98 = 564·0	551·0	557·5

The remaining line, $H\beta$ seems from its image to be due to the light of the whole nebula. The two 18·51 and 18·98 seem to be due to the light of the Nova.

It is of interest to compare the wave lengths obtained above with the wave lengths of the coronal lines 1474 and 1250 ± 30, lines which also appear in the spectrum of the solar protuberances. The wave length of 1474 is 531·59, that of 1250±30 is 556·05±3·44.

While it may be too much to claim that these measures afford an absolute proof of identity, yet certainly the strong suspicion is not without interest, importance and suggestiveness.

Although it has no immediate connection with the subject of the present article, it may not be out of place to note the presence of these 18·5 and 19·0 lines in the spectra of γ Cassiopeiæ and β Lyræ. Concerning these spectra we hope to speak later.

Observatory of Yale College, Oct. 1, 1885.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the determination of the Specific Density of liquids at high temperatures.*—R. Schiff has described a convenient form of apparatus for determining the specific density of liquids at high temperatures, based on the principle of the weight thermometer. The pyknometer itself consists of a cylindrical glass vessel of 8 to 10 c. c. capacity, with a conical neck terminating in a fine opening. Upon this conical neck a recurved glass cap or helmet is ground air tight. The instrument is placed in a funnel-shaped vessel, the tube of which passes through the cork of a flask placed beneath it, containing the liquid by means of whose vapor the apparatus is to be heated. At top the funnel has three openings; through one the excess of vapor passes to an inverted condenser, through the second, a thermometer is inserted; and through the third, which is central and larger than the others, passes (1) a wire holder to support the pyknometer, and (2) a glass stem to which the cap or helmet is attached and by means of which this may be made to close the opening in the specific density flask. To make an observation, the flask is filled with the liquid to be examined, a small glass plug being used to close it during the weighings, and is supported within the funnel. As the temperature rises, the liquid expands and overflows into the recurved portion of the helmet. When the temperature has become uniform, the instrument is removed from the vapor, allowed to cool and weighed. The difference between the first and second weighings gives the overflow. This divided by the weight of the substance remaining gives the expansion of the substance per weight-unit. And, knowing the volume of the flask at 0° and its expansion-coefficient (determined by making two experiments with mercury, one in ether vapor at 34° and the other in steam at 100°), the specific density is readily calculated. —*Ber. Berl. Chem. Ges.*, xviii, 1538, June, 1885. G. F. B.

2. *On the direct union of Bromine with Chlorides, forming a new class of Perbromides.*—In a series of experiments upon the reaction which takes place between bromine and certain chlorides, BERTHELOT has observed the formation of a new group of secondary compounds produced by the direct addition of bromine to these chlorides, in strict analogy to the formation of the alkali perbromides. When for example fuming hydrogen chloride, of specific density 1·153, is mixed with bromine, 100 c. c. dissolve within a few minutes 36·4 grams of the bromine; increasing finally to 40·1 grams. The ratio between the two is 36·5 to 40·1; which corresponds to the formula $(HCl)_2Br$. This fact, as well as the calorimetrical one that the heat evolved in the reaction is double that evolved when bromine is dissolved in water, proves, in the author's opinion, the formation by direct union of a bromide of hydrogen chloride, comparable to hydrogen perchloride. Analysis showed that at most only one three-hundredth of one equivalent of the chlorine had been replaced. This fact as well as the ready dissociation of the compound shows that the bromine has acted by direct union and not by substitution. Hydrogen chloride dissolves iodine also in much larger proportion than water, one liter dissolving 6·04 grams; thus indicating the formation of a similar periodide. A solution of barium chloride containing 450 grams of the crystallized salt to the liter dissolves 115 grams bromine, nearly four times the quantity dissolved by the same quantity of pure water. The heat evolved is 0·5 calory for Br liquid = 80 grams. The solution may be diluted with its own volume of water without throwing down the bromine. Only one hundredth of an equivalent of the chlorine suffered replacement in this experiment. A solution of strontium chloride containing 400 grams of the crystallized salt to the liter, dissolves 92 grams of bromine, three times as much as pure water. The same kind of absorption has been observed with silver chloride.—*Bull. Soc. Ch.*, II, xliii, 545, June, 1885. G. F. B.

3. *On the Reduction of Carbon dioxide to monoxide by Carbon.* NAUMANN and PISTOR have studied the conditions, especially of temperature, under which carbon dioxide is reduced to monoxide through the action of carbon upon it. In the first five experiments (which were conducted at comparatively low temperatures in order to determine the lower limit at which the reduction took place) a combustion tube 82 cm. long and 15 mm. in diameter, was used, filled with fragments of charcoal previously washed with acid and then strongly ignited. Through this tube the carbon dioxide, prepared from marble and hydrogen chloride and carefully dried, was passed at the rate of 2 or 3 bubbles per second; the tube being heated in a gas furnace, and being surrounded with two concentric sheet iron tubes enclosing wire spirals, for the purpose of rendering the temperature more uniform. In order to measure the temperature, a number of capsules of glass or platinum, containing salts of different melting points and for

the higher points, metallic spirals, were distributed at intervals within the tube. If at a given time one of these salts is observed to be melted and another not, the temperature of the tube obviously lies between the two melting points. In the first experiment, in which the temperature never reached 530° (since silver iodide, fusing point 530°, was never melted and even lead chloride, fusing point 501°, was softened only in the middle of the tube) the layer of charcoal being 66 cm., the evolved gas during the entire hour was completely absorbed by potassium hydrate; showing that no reduction had taken place. In the second, in which the temperature remained below 585° (the fusing point of silver pyro-phosphate) a minute quantity of non-absorbable gas, burning with a blue flame, was obtained. This temperature 530° –586° marks the limit of the reduction. In the third, silver iodide was completely fused, silver pyrophosphate sintered together, but lithium chloride (fusing point 602°) remained unaltered. The evolved gas contained 12·6 per cent carbon monoxide. In the 4th experiment the layer of charcoal was reduced to 10 cm. and it was found that no action took place even at 602°; so that in the fifth experiment, carbon monoxide gas was observed only when the temperature lay between the melting point of potassium iodide (634°) and that of potassium bromide (703°). The glass tube was then replaced by one of porcelain 8 mm. in diameter, which was heated in a Fletcher gas furnace, using an air blast. In the sixth the carbon layer being 30 cm. long, the temperature did not reach 814° (the fusing point of Na_2CO_3) 90 c. c. of gas were collected in 16 minutes and the CO present in the evolved gas was 12·7 per cent. In the 7th, with a layer of charcoal 24 cm. long, and the temperature about 861° (the fusing point of Na_2SO_4) the gas evolved at the rate of 1·7 bubbles per second consisted of 58·7 CO and 41·3 CO_2. In the 8th, the carbon layer was only 10 cm. long, silver was melted, (954°) but copper was not (1054°) and the gas (1·2 bubbles per second) consisted of 94·2 CO and 5·8 CO_2. In the 9th, the carbon layer was 57 cm. long, the temperature above 861° but below 954°, the gas passed at the rate of 3 bubbles per second and contained 90·7 per cent of CO. In the 10th experiment a platinum tube 5 mm. in diameter was used, the carbon layer being only 2 mm. long. In 4·25 minutes 70 c. c. of gas were collected (about 3 bubbles per second) of which 18·1 per cent was CO. In the 10th experiment, the tube was filled with alternate layers of charcoal and of copper turnings, the former amounting in all to 10 cm., the latter to 34 cm. The temperature in the greater part of the tube was between 861° and 954°. The gas passed at a rate of 2 bubbles per second and contained 36·5 per cent of CO. From these experiments the authors conclude: 1st, that the reduction of carbon dioxide to carbon monoxide by carbon has its lower temperature-limit at about 550°. 2d, that if according to theory, the reduction at a given temperature is proportional to the frequence of the contacts between the carbon dioxide and the car-

bon, then an increase in the length of the carbon layer or a decrease in the velocity of the gas-current, should increase the amount of monoxide produced, as is shown in the 7th and 9th experiments. 3d, that the reduction increases with the temperature. The paper concludes with a discussion of the thermochemical questions involved in the results obtained.—*Ber. Berl. Chem. Ges.*, xviii, 1647, July, 1885. G. F. B.

4. *The Decomposition of Carbon dioxide by the Electric spark.*—In consequence of an observation showing that no explosion is propagated by a spark in a mixture of carbon monoxide and oxygen which has been dried over phosphoric oxide, made by DIXON, he has undertaken, assisted by LOWE, the study of the action of the electric spark upon carbon dioxide when similarly dried. The gas carefully dried over phosphoric oxide, was placed in a eudiometer and, by means of a chain composed of short pieces of platinum fused into small glass beads, was submitted to the action of a series of induction sparks. The amount of decomposition varied from time to time, but approached no fixed limit; the maximum decomposition being about 45 per cent under 100 mm. pressure. Placing a condenser in the secondary circuit, diminished the effect. To test the effect of varying the length of the spark, a eudiometer was next employed which had two pairs of platinum wires, the ends being 1·5 mm. and 6 mm. apart respectively. On passing the spark through 52·10 c. c. of the perfectly dried gas, between the former terminals, the volume began soon to increase, attaining finally 62·34 c. c.; showing a decomposition of 39·08 per cent of the CO_2 into CO and O. In a second experiment in which the sparks passed continuously for six hours, the decomposition was 33·97 per cent. When the spark passed through the wider space for five hours, the decomposition was 30·20 per cent. Returning to the shorter spark the coil was left running over night with one cell of battery. In the morning it had stopped and the decomposition was 43·33 per cent. In these experiments the pressure was about 500 mm. and the temperature varied from 10° to 15°. It is therefore clear that the shorter spark produced the greater decomposition. Since the variations of volume due to changes in the nature of the electric discharge, mask the effect of varying pressures, a differential process was resorted to. Two similar eudiometers were prepared and fitted with wires made of platinum-iridium alloy, each terminating in a 2 mm. ball, the distance between them being the same in the two tubes. When a series of sparks was sent simultaneously through both tubes containing dry CO_2, the effect was the same in both, the volumes varying together so long as the pressure was preserved constant. The greater decomposition was produced by the feebler spark and under the less pressure. When 100 volumes of dry CO_2 were placed in one tube and 150 volumes of a dry mixture of carbon monoxide and oxygen were placed in the other, and a series of sparks from the same coil was passed through both, the volume of CO_2 increased and that of the CO

and O diminished until after some hours they became equal under the same pressure. On continuing the spark the volumes in the two tubes altered together, increasing or diminishing as the nature of the spark varied. Since a white-hot coil of platinum wire produces no permanent alteration of volume in dry CO_2; and since Deville has shown the dissociation of CO_2 in contact with white hot platinum; it follows that the dissociated CO and O must at once reunite under these conditions. Hence the author predicted that a white hot platinum wire would produce complete combination of dry CO and O, even without explosion. On heating the platinum coil to redness in the carefully dried mixture, it at once glowed intensely and in a few minutes complete combination was found to have taken place. From this result the authors conclude that while hydrogen unites with chlorine and iodine directly, carbon monoxide and oxygen require an intermediary to effect their combination.—*J. Chem. Soc.*, xlvii, 571, August, 1885.

G. F. B.

5. *On the direct synthesis of Benzene derivatives by the action of Potassium on Carbon monoxide.*—NIETZKI and BENCKISER have repeated Lerch's experiments on the explosive compound of potassium and carbon monoxide which is formed in preparing this metal, and have proved that the derivatives he obtained from it, trihydrocarboxylic, dihydrocarboxylic and carboxylic acids are identical with the hexaoxybenzene, tetraoxyquinone and dioxydiquinoylbenzene respectively, already described by them. The carbonyl-potassium was obtained by passing a current of CO, completely dried and freed from oxygen, over potassium heated to melting in a combustion tube. At the close of the experiment the potassium had increased in weight about 70 per cent; confirming Brodie's view that one molecule of CO was absorbed for each atom of K. The product was a solid grayish mass with here and there patches of a red-brown, green or black color. After cooling, the tube may be filled with strong alcohol without danger of explosion. On treating the crude product with hydrogen chloride, hexaoxybenzene $C_6(OH)_6$ is produced, which proves that the carbonyl-potassium is most probably $C_6(OK)_6$ or potassium-hexaoxybenzene. The former is accompanied however by tetraoxyquinone, its first oxidation product from which it may perhaps be formed during the solution in HCl, by the reducing action of the K still present upon the corresponding potassium compound directly produced: $(CO)_6+K_4=C_6(OK)_4O_2$. To ascertain this the freshly-prepared carbonyl-potassium was dissolved in acetic oxide and precipitated by water. The brown precipitate crystallized from glacial acetic acid gave the characteristic hexaacetylhexaoxybenzene. The residue after treating the crude product with alcohol is a dark green powder, which turns red in the air, and which boiled with HCl dissolves with a brownish red color. On cooling the solution deposits stellate groups of steel-blue needles of tetraoxyquinone $C_6(OH)_4O_2$. If the crude product be washed with dilute alcohol it turns red and finally

produces an ochre-red powder, the so-called rhodizonic acid. This the authors find to be identical with their dioxydichinoylbenzene $C_6(OH)_2O_4$.—*Ber. Berl. Chem. Ges.*, xviii, 1833, July, 1885.

G. F. B.

6. *Composition of Ocean water.*—Mr. W. Dittmar has given (Proc. Phil. Soc. Glasgow, vol. xvi, Dec. 3, 1884) a summary of his results obtained in the investigation of the specimens of ocean water brought home by the Challenger expedition. We cite briefly from this abstract. Mr. Dittmar remarks in the outset on the small change in the constitution of the solids in solution in the ocean produced by the contributions of rivers, stating that the estimated annual amount from the thirteen principal rivers of the earth, $1{\cdot}337 \times 10^9$ tons (of 1000 kilos each), when compared with the amount in the ocean water of dissolved solids (46,280 billion tons in the 1·3 trillion tons of water), is so small that it would take 30,000 times as much to tell distinctly on the most exact sea-water analysis which could be made by our present methods.

The water was found to contain an appreciable amount of base over and above that which would neutralize the two principal acids, and this is in the state of *carbonate;* and part of this carbonate must be carbonate of lime. From the mean results of 77 analyses, this surplus base per 1,000 grams of ocean water is equivalent to 0·25 grams of carbonate of lime; but this number may need a correction, considered beyond. The following table gives the results of Mr. Dittmar's 77 analyses:

Average composition of Ocean-water Salts.

	Per 100 parts of Total Salts.	Per 100 of Halogen calculated as Chlorine.	
	Dittmar.	Dittmar.	Forchhammer.
Chlorine	55·292 } *	99·848	Not determined.
Bromine	0·1884 }	0·3402	Not determined.
Sulphuric acid, SO_3	6·410	11·576	11·88
Carbonic acid, CO_2	0·152	0·2742	Not determined.
Lime, CaO	1·676	3·026	2·93
Magnesia, MgO	6·209	11·212	11·03
Potash, K_2O	1·332	2·405	1·93
Soda, Na_2O	41·234	74·462	Not determined.
(Basic oxygen equivalent to the halogens)	(−12·493)	----	----
Total salts	100·000	180·584	181·1

Combining acids and bases, we have (Dittmar)—

Chloride of sodium	77·758
Chloride of magnesium	10·878
Sulphate of magnesium	4·737
Sulphate of lime	3·600
Sulphate of potash	2·465
Bromide of magnesium	0·217
Carbonate of lime	0·345
Total salts	100·000

* Equal conjointly to 55·376 parts of chlorine, which accordingly is the percentage of "halogen reckoned as chlorine" in the *real* total solids.

Reducing to the absolute mass of the ocean as given above, we arrive at the following numbers :

Absolute composition of the Salts of the Ocean.

UNIT=1 BILLION=10^{12} TONS.

Chloride of sodium	35990
Chloride of magnesium	5034
Sulphate of magnesium	2192
Sulphate of lime	1666
Sulphate of potash	1140
Bromide of magnesium	100
Carbonate of lime	160
	46283
Total bromine	87·2 (W. D.)
Total iodine	0·03 (Köttstorfer.)
Total chloride of rubidium	25·0 (C. Schmidt.)

Mr. Dittmar adopted Tornoe's expression numerically for the *alkalinity* of the water by stating the number of milligrams of CO_2 which would convert the surplus base into normal carbonate, and referring it to one litre of sea-water analyzed, or—to get rid of degree of salinity—referring it to 100 parts by weight of total salts in the water, or to 55·42 parts of halogen counted as chlorine. The statement that the alkalinity = ·154 signifies that per 100 parts of total salts the water contains 0·154 parts of CO_2 as normal carbonate, or rather in the $R''O,CO_2$ part of the carbonate as formulated. The alkalinity ranged from 0·140 to 0·164, with a tendency to the highest results in the bottom waters. One cause of more lime carbonate in the bottom waters is found in the shells of dead crustaceans, etc., over the bottom. Some free CO_2 also may be present.

The *salinity* of the waters is oceanographically a function of the geographic position, depth, and time. Mr. Dittmar determined, from comparisons of ascertained specific gravities with chlorine determinations, that the per-millage of chlorine in an ocean water at a given temperature is proportional to the excess of its specific gravity above that of pure water at the same temperature. This is expressed in the formula,

$$_4S_t - {}_4W_t = \chi(a + bt + ct^2),$$

where $_4S_t$ denotes the specific gravity of sea-water, and $_4W_t$ that of pure water at $t°$, both referred to pure water at $+4°$ C. as $=1000$, while a, b, and c are constants having the values

$$a = 1·45993,\ b = -0·0055922,\ c = 0·0000649.$$

The results agree closely with the determinations of specific gravities of Challenger waters by Mr. Buchanan, of the Challenger expedition.

The *atmospheric constituents* of the waters were also studied. Buchanan followed Jacobsen's method in collecting the gases from the waters. Mr. Dittmar found that in the surface waters the oxygen and nitrogen vary in amount from temperature, but the

waters nowhere contain more than 15·6 c.c. of nitrogen or more than 8·18 c.c. of oxygen per liter; and that the nitrogen never falls below 8·55 c.c. The oxygen is diminished below its theoretical minimum 4·30 c.c. by the processes of life and organic decomposition and other oxidation changes. In waters at depths the variation in amount of oxygen is greater, because of the feeble source of supply and the losses from oxidation. No deep-sea water was found, in the analyses, wholly without free oxygen, and this "confirms the conviction that absolute stagnation nowhere exists in the ocean, not even at its greatest depths." But in one sample the amount of cubic centimeters per liter was found to be 15·08 N_2 and 0·6 O; in another 13·38 N_2 and 2·04 O; "indicating approximate rest at these two places at any rate." At the ocean's surface the equilibrium in the absorbed nitrogen and oxygen is maintained by the atmosphere.

As to *carbonic acid in sea-water*, all the waters were found to contain it, and those from the deep sea were particularly rich in it. The analyses prove that "if sea-water anywhere contains free CO_2 at all, it amounts to little in comparison even with the combined CO_2 of the carbonates." But sea-water may give off CO_2 even when only enough is present to make all the lime bicarbonate. Experiments showed that the loss may continue until there remains only what is necessary to make the lime a sesquicarbonate. "In surface waters the proportion of carbonic acid increases when the temperature falls, and vice versa;" and "within equal ranges of temperature it seems to be lower in the surface water of the Pacific than it is in that of the Atlantic Ocean." Free carbonic acid is, however, occasionally in rather large proportion, 22 out of 195 waters analyzed by Mr. Buchanan having their surplus base at least fully saturated, and one, although a surface water at 25·1° C., contained as much as 41 milligrams of free CO_2 per liter."

The total weight of potential carbonate of lime in the ocean amounts to 160 billion tons, equal to 70 such units of CO_2; but as the CO_2 is present as partially saturated bicarbonate, 105 billion tons may be accepted as a rough approximation. The source of this CO_2 Mr. Dittmar supposes to be from submarine volcanic action. As volcanoes get the CO_2 by decomposing limestone about the conduit, it would in that case come from the calcareous material of the ocean's depths, or from the earth's crust beneath, set free by volcanic heat.

The total weight of loose CO_2 in the ocean is at least 15 times greater than that of the free CO_2 in the air. If the amount of lime carbonate contributed by all the rivers of the world is assumed to equal the total solids which the thirteen rivers before named contribute, $1{\cdot}3375 \times 10^9$ tons, it would take them 1194 years to increase the amount in the ocean one per cent of its present value, the sum total of the carbonate of lime of the ocean being 160 billion of tons.

II. Geology and Mineralogy.

1. *On the development of Crystallization in the Igneous rocks of Washoe, Nevada, with notes on the Geology of the District;* by Arnold Hague and J. P. Iddings. Bulletin No. 17 of the U. S. Geol. Survey. 44 pp. 8vo. Washington, 1885.—This memoir is one of the most important and wide-bearing that has come from the U. S. Geological Survey. It is "the result of an investigation of the extensive and well-selected lithological material collected by Mr. G. F. Becker during his examination of the geological lode;" and illustrates the fact—doubted and denied by many geologists—that the rock of an igneous eruption may vary in crystallization from true lavas of glass-containing igneous rocks in an upper or outer region, to completely crystalline kinds, granite-like in texture, in a lower or inner region.

The grand section through igneous rocks—over four miles long—afforded by the Sutro tunnel, and the vertical sections in shafts 2,000 to 3,000 feet deep, make the Washoe region especially favorable for such an investigation. The great differences between the rocks of the territory led Mr. Becker, in his report, to recognize, in accordance with German teaching, two groups among them, a Tertiary and a pre-Tertiary; and the same distinction was made out in his study of the rocks met with on descending in the mine, the lower being of the older division. The specimens collected in his careful investigation of the region number more than 2,000, 600 of them from the surface rocks, and over 1,400 from underground. The rocks made out by him were granular diorite, porphyritic diorite, micaceous diorite-porphyry, quartz-porphyry, earlier-diabase, later-diabase, earlier-hornblende-andesite, augite-andesite, later-hornblende-andesite, basalt.

Messrs. Hague and Iddings, after a microscopic study of thin sections of the various rocks (over 500 in number), have obtained the following results.

The study of the *diabase* and *augite-andesite* (of which there were 140 thin sections) shows, *first*, "the absolute identity," in nature and occurrence, of the mineral constituents of the two rocks, so that many kinds under each are not distinguishable; *secondly*, a gradual transition from a microlitic glassy groundmass to a holocrystalline; and from microscopically fine-grained to coarse-grained and porphyritic varieties. These two points are established by finding imperceptible gradations, in all respects, between the diabase and augite-andesite. A study of the successive rocks along the Sutro tunnel sustains the conclusions that the glass-bearing rocks are the exterior; that the degree of crystallization increases inward; that the two kinds of rocks here considered are for the most part indistinguishable.

The *granular-diorite*, at the head of the Sutro tunnel, was proved to belong with the pyroxene rocks. The same rock from Mt. Davidson and Ophir Ravine was found to be identical with the coarse-grained diabase.

Porphyritic diorite and *Earlier-Hornblende-andesite.* All shades of gradations between these two rocks occur. Transitions from glassy varieties to the most crystalline are well seen about Mt. Davidson and elsewhere. A comparison of sixty thin sections failed to make out any distinguishing features. Some of these *Earlier* Hornblende-andesites are glass-bearing.

Mica-diorite and *Later Hornblende-andesite.* For the latter rock the name hornblende-mica-andesite is stated to be better, as the mica is an essential ingredient, and distinguishes it from the earlier-hornblende-andesite. But from the varieties of mica-diorite it is indistinguishable; there is great variation in macroscopic aspect and this makes more forcible "the absolute identity of the two rocks." The coarsest variety of the mica-bearing diorite is "*thoroughly granite-like in all its mineral constituents,*" while at the other end of the scale of gradations there are kinds having a glassy ground-mass crowded with microlites, and these are the surface kinds.

Quartz-porphyry, Dacite and *Rhyolite.* These rocks were made pre-Tertiary by von Richtofen and Becker, and Tertiary by Mr. Clarence King; and the latter conclusion is that of Messrs. Hague and Iddings. They are for the most part rich in crystals of quartz, feldspar and mica, with some hornblende, but the dacite contains less quartz and less hornblende. The examination leads to the conclusion, that while there are great variations in texture, color and density, there exist no petrographic distinctions between them.

Younger-Diabase, Black Dike, Basalt. The younger-diabase, a pre-Tertiary rock, occurs as a narrow dike for more than a mile along the lower levels of the Washoe mines; its upper part makes the Black Dike. A comparison of thin sections of the surface basalt and the diabase shows that there are no petrographic distinctions between these olivine-bearing rocks.

The comparisons of these various rocks as regards chemical composition—using analyses in Becker's work, with three new ones—sustains the close similarity of the augite-andesites, hornblende-andesites and hornblende-mica-andesites. The silica in augite-andesites and hornblende-andesites varies most in percentage, but only from 56·40 to 60·82. The hornblende-mica-andesites and mica-andesites have 63·30 to 65·68 per cent of silica. Silica determinations of five pyroxene-andesites and hornblende-andesites from other localities (near the base of Mt. Davidson), give for the silica 55·66 to 57·06 per cent, showing remarkable uniformity.

The authors conclude:

That the degree of crystallization developed in igneous rocks is mainly dependent on the conditions of heat and pressure under which the mass has cooled, and is independent of geological time. The same magma has given origin to the most glassy and the most granite-like kinds, the most modern-looking and the most ancient-looking, the glassy kinds occurring at or near the surface,

while those at considerable depths cooled slowly and became wholly crystalline in texture.

That all the Washoe regions are of Tertiary age.

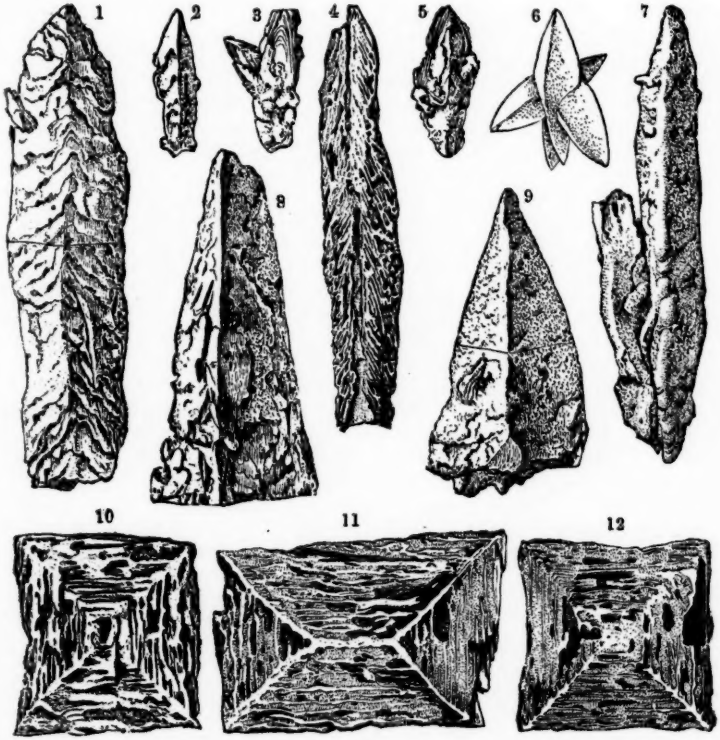
That the so-called granular diorite, diabase, and augite-andesite are identical and belong to the same geological body; that the porphyritic diorite and hornblende-andesite are identical, and should bear the latter name; that the so-called mica-diorite is identical with the later-hornblende-andesite; that the quartz-porphyry resolves itself into both dacite and rhyolite; that the later-diabase and the basalt are one in rock, the former known as a dike and the latter in flat-topped masses.

That the Comstock lode occupies a fissue along a line of faulting in a rock of Tertiary age, and cannot be considered as a contact vein between two different rock-masses.

The facts from the great sections of Washoe rocks so carefully investigated are of fundamental importance to petrography. As far as igneous rocks are concerned, they seem to demolish the system of rock-classification now most popular; for, taking out the distinctions of *earlier* and *later;* and that of granitoid, microcrystalline and glass-bearing, among rocks and groups of rocks, the system goes to pieces, and the definition of *species* or *kinds* among rocks will have to fall back, with some exceptions, on the reasonable ground of mineral constitution irrespective of age and texture. J. D. D.

2. *A crystallographic Study of the Thinolite from Lake Lahontan;* by EDWARD S. DANA (Bulletin of the U. S. Geol. Survey, No. 12).—The calcareous tufas of Lake Lahontan, the great Quaternary lake of northwestern Nevada, were called thinolite by King in his Report of the Survey of the 40th Parallel, in allusion to the fact that they were a shore deposit (*Θί's*, shore). Of these tufas a certain limited portion is crystalline in character, and a study of its forms, as remarked more particularly later, led Mr. King to the conclusion that it was a pseudomorph after the mineral gay-lussite; and he bases his explanation of the history of the lake upon this hypothesis. The relations of the tufas of Lake Lahontan have been since then thoroughly studied by Mr. I. C. Russell. He shows that there are three distinct varieties, the *lithoid* or stone-like, the *thinolithic*, or crystalline and the *dendritic;* these were deposited at different stages in the Lake's history in the order named. The chief interest attaches to the crystalline variety, or thinolite proper, and it is to the description of this that the Bulletin No. 12 is devoted. It is found well developed at a number of different points in the Lahontan basin, conspicuously about Pyramid Lake, and outside of it in that of Mono Lake; where best exposed it forms a layer of interlacing crystals six or eight feet in thickness. Chemically the thinolite consists of almost pure calcium carbonate. As regards general aspect, many varieties are found, from the open, delicately porous form, skeleton-like in character, to that which is firmly compact and has a smooth exterior. The form of the

individual crystal is roughly either that of a rectangular prism, often with projecting edges and generally tapering off toward the extremities (see figs. 1, 4, 7, 8), or that of an acute square or rhombic pyramid (fig. 9). Crystals of the former kind are usually grouped in a more or less closely parallel position with but little interlacing, the individual crystals having a length up to 8 or 10 inches; when the crystals are smaller, however, they interpenetrate each other and give the mass a reticulated aspect.



The distinctly pyramidal crystals are generally small and project from the mass in all directions.

Of the true crystalline structure of the thinolite but little can be definitely concluded from the external examination of the specimens. It is only when sections have been cut, transverse and longitudinal, that the form is revealed. The transverse sections show uniformly a system of square or rectangular ribs with others in a diagonal position, intersecting at an angle of about 90°. In the porous kinds the section cut shows these ribs alone,

the intervening spaces being open; this is illustrated in fig. 10, which is a section cut across the crystal shown in fig. 1 at the point indicated. In the more compact varieties the spaces between the skeleton ribs, which uniformly consist of granular calcite, are more or less completely filled with amorphous calcite, often in concentric layers; this is shown in fig. 11 cut from the base of the crystal shown in fig. 8, and still more in fig. 12 cut at the point indicated from the crystal shown in fig. 9. A longitudinal section of a crystal resembling fig. 1 is shown in fig. 4 and reveals a system of plates converging toward one extremity at an approximate angle of 35°.

The arrangement of the system of plates of which these pseudomorphous crystals are made up, as shown in the figures, proves that the crystals conformed approximately to the type of an acute square pyramid. The structure of numerous dissected crystals, as shown in figs. 2, 3 and 5, which are not uncommon in some of the specimens, conforms to this type; as does also the external form whenever distinct. Provisionally then it is concluded that the original mineral, after which the thinolite is a pseudomorph, crystallized in the tetragonal system in acute pyramidal forms. The crystals might equally well be referred to an orthorhombic or monoclinic form approximating to the tetragonal, but the simpler hypothesis seems the more probable.

Only a negative conclusion as to the nature of the original mineral is definitely reached, viz: that it could not have been gay-lussite, nor gypsum, nor anhydrite, nor in fact any known mineral. It is suggested, however, in view of the fact that the crystals resemble in form the pseudomorphs of lead carbonate after phosgenite ($PbCO_3+PbCl_2$), that the original mineral in this case may have been an isomorphous salt with the composition $CaCO_3+CaCl_2$, or perhaps $CaCO_3+2NaCl$. The value of such a hypothesis will have to be tested by synthetic methods.

In conclusion the writer calls attention to the resemblance of many of the thinolite forms (cf. fig. 6) to the well known barley-corn pseudomorphs of Sangerhausen, long referred to gay-lussite, although that explanation was shown by DesCloizeaux to be erroneous. It was this resemblance which chiefly led Mr. King to refer the thinolite also to gay-lussite. Pseudomorphs of calcium carbonate apparently identical with those from Sangerhausen have been described from half a dozen other localities, and it is suggested here that probably all of them, and the thinolite also, were derived from the same original mineral. The ultimate solution is therefore much to be desired on this account, as well as because it is so important in explaining the geological history of Lake Lahontan.

3. *Address before the Geological Section at the recent meeting of the British Association at Aberdeen*, by the President of the Section, Prof. J. W. JUDD.—In his able address at Aberdeen, Prof. Judd reviews historically, *first*, the problem of the Scottish Highlands; *secondly*, that of the Elgin sandstone; *thirdly*, the relations between Scottish and Scandinavian geology; *fourthly*,

the extent, effects and geological history of faultings and denudation, particularly in the Scottish Mountain region.

With regard to the Highland controversy he points out that Macculloch, nearly seventy years ago, took the first right steps in the investigation of the region, proving the existence of a great formation of red sandstones and quartzyte, distinct from the "Old Red," and finding some fossils in the quartzytes that have since been proved to be Paleozoic; and recognizing its unconformability to underlying crystalline rocks and its being overlaid with apparent conformability by other crystalline schists and gneisses. In 1854, Mr. Charles Peach discovered other fossils in the formation which settled the question as to Paleozoic age. In 1856, Prof. Nicol showed that Macculloch's "Primary Red Sandstone" formation, included two series, an upper fossiliferous, and a lower unfossiliferous which was unconformable to the rest; and to the latter he gave the name of the Torridon sandstone. In 1859 he reached, in opposition to other investigators, the conclusions which are now admitted facts, even to the latest—that the apparently conformable succession of this early Paleozoic series into overlying schist and gneiss, was "due to the thrusting of the crystalline rocks over the sedimentary by great overthrow faults" comparable with those found in the Alps. These results were published by Professor Nicol in the Quarterly Journal of the Geological Society for 1861. The conclusion was afterward supported by some other observers, but it took more than twenty-five years for his results to gain general acceptance.

The review of the close relations between Scottish and Scandinavian geology as regards geography, strata, mountains and mountain-making, faulting and denudation, is of special interest. The Scottish Highlands, with the Hebrides and Donegal, Orkney and Shetland, are, Prof. Judd observes, "mere outliers of the Scandinavian peninsula;" and geographical separation took place as late as the Glacial era.

He recognizes fully the light with regard to the mountain formations which the Highlands received from the work of Prof. Rogers on the Appalachians. But he does not see fit to give credit for the principle that, among crystalline rocks, lithology may serve as a substitute for paleontological evidence; and he even throws discredit on the term "fundamental gneiss" of Murchison. His views on this point we fully endorse; and one sentence is almost in the words of an article by the writer read in August last before the geological section of the American Association. We cite a paragraph:

"I confess that, speaking for myself, I am not sanguine as to the success of such endeavors. The miserable failures which we have seen to have attended similar attempts, in the case even of far less altered rocks, where identifications have been based on mineralogical resemblances only (and in connection with which definite paleontological or stratigraphical evidence has been sub-

sequently obtained) ought surely to teach us caution in generalizing from such uncertain data. It has been argued that, where paleontological evidence is wholly wanting, and stratigraphical relations are doubtful or obscure, then we may be allowed to avail ourselves of the only data remaining to us—those derived from mineralogical resemblances. But surely, in such cases, it is wiser to admit the insufficiency of the evidence, and to say 'We do not know!' rather than to construct for ourselves a 'fool's paradise,' with a tree of pseudo-knowledge bearing the Dead-Sea fruit of a barren terminology! The impatient student may learn with the blind poet that

They also serve, who only stand and wait.

It is thought by some that the application of the microscope to the study of rock-masses may reveal peculiarities of structure that will serve as a substitute for paleontological evidence concerning the age of a rock when the latter is wanting. Greatly as I value the insight afforded to us by the microscope when it is applied to the study of the rocks, and highly as I esteem the opinions of some of those who hold these views, yet I fail to see that any such connection between the minute structure and the geological age of a rock has as yet been established."

He later states, with regard to certain Cambrian beds in Scandinavia, that Kjerulf believes there is evidence of their passing horizontally into true gneiss; and adds that "similar appearances are not wanting in the case of our Torridon sandstone," which he is disposed to refer to the same age, though leaving the question open as it has afforded yet no fossils.

The fossiliferous beds overlying the Torridon Sandstone containing "Primordial" forms of trilobites are either true Cambrian or the equivalent of the American Calciferous and Chazy. The Triassic rocks of Scandinavia are described as undistinguishable in all their features from those of the Highlands. On both sides of the North Sea they pass up insensibly into Rhætic and Infra-lias beds, of marine and estuary origin having vast thickness, though thin in England, and having coal seams, and in Scania many plants of several distinct floras. Over these in each country are Jurassic beds, 3000 to 4000 feet thick, with other coal beds and abundant Ferns, Cycads and Conifers; and the upper Jurassic beds in Sutherland bear evidence of forests of such trees, and at the same time of transportation on large rivers, at certain seasons, of bowlders of vast dimensions by floating ice. The following epoch of the Neocomian was apparently a time of emergence and great denudation; but the beds of the Cretaceous once covered large areas in the Scottish Highlands and Scandinavia. The Tertiary period left few stratified deposits in either land, but was an era of great sub-aerial denudation, stripping the country largely of Mesozoic and older strata "except where buried deeply by gigantic earth-throes or sealed up under lava streams." In the west of Scotland a chain of volcanic mountains with summits towering to the height of 10,000 to 15,000 feet have

been reduced by this same denudation to heights of little more than 3000 feet. Dislocations of one, two and perhaps three miles in amount, parallel in general to the Highlands (N.E. and S.W.) have occurred in Paleozoic, Mesozoic, Cretaceous and Tertiary times. "Great strips of Triassic and Old Red Sandstone strata, like those of Elgin and Turriff and Tomiutoul, and of the line of the Caledonian Canal, are found let down among the crystalline rocks by the gigantic faults," and in the Western Highlands displacements of several thousands of feet affect the older Tertiary rocks. The great central valley of Scotland consists of Newer Paleozoic strata faulted down between the Archæan and Older Paleozoic of the Highlands on one side and the Borderland on the other. Fissures, injected by lavas from the great Tertiary volcanic foci of the Western Isles and Antrim, cross the Highlands, the central valley, the Borderlands of Scotland and the region of secondary rocks in Northern England.

The address of Prof. Judd is a very valuable contribution to the great subjects of mountain disturbances and denudation, and also to other topics connected with the geology of the higher latitudes. J. D. D.

4. *Results of the fusion of pyroxene and hornblende minerals.*—The Geological Zeitschrift, volume xxxvii (p. 10) contains an article, by Mr. Arthur Becker, entitled "Fusion experiments with pyroxene and amphibole minerals, and observations on olivine grains." The object of the experiments was to ascertain "whether the crystalline system of these minerals was determined absolutely by their chemical composition." For this purpose the author fused a number of specimens of pyroxene and hornblende in a furnace and kept them as near the melting point as possible for from 8 to 36 hours, and then allowed them to cool slowly. He succeeded in obtaining in most cases an almost completely crystalline mass, the characters of whose crystals he carefully studied with the microscope. Of the orthorhombic system, he treated hypersthene, bronzite, enstatite and anthophyllite; of the monoclinic, augite and hornblende; and of the triclinic, rhodonite, fowlerite, babingtonite and bustamite.

The following are the results of his experiments. Although not deciding with certainty whether the fused triclinic minerals cooled in the triclinic or the monoclinic system, yet, in view of the very great resemblance to the mineral in the unchanged state, he infers that the original form is retained. As to the orthorhombic and monoclinic pyroxene and amphibole minerals, the experiments proved that, when melted and cooled under the conditions stated, they "crystallize again in the same systems to which the original minerals belonged; but that the members of the hornblende series cool as augite."

The hornblende from Wolfsberg in Bohemia yielded results of especial interest. In the first experiments the fused mineral exhibited in the glassy ground-mass numerous large brown-violet, sharply defined augites, and a very large amount of small bright

augite-microlites, for the most part rounded. The other experiment, "in which the temperature of the fused mass during the formation of the crystals was, at least at the beginning, somewhat higher," gave a product consisting of a brown glassy substance out of which some whole and many fragmentary crystals of olivine projected, which contained numerous inclusions of the ground-mass." The olivine, he says, according to his experiments and those of others, easily forms from liquid fusion (provided, of course, the chemical composition of the magma allows) when it is kept for a long time at a pretty high temperature. Besides a considerable number of brown irregularly defined weakly-polarizing and somewhat dichroic folia separate out, such as Mr. Becker had obtained in a former experiment. In some of these an extinction angle of 2°–5° in the longer direction was observed. They are, according to this experiment, new formations and not incompletely dissolved mineral particles. He observes that similar brown scales exist sometimes in natural basalts, and questions whether this is so because the basaltic hornblende, which melts more easily than augite, was again made liquid by additional heat and then, in cooling, as in this experiment, separated into olivine glass and this compound. A. G. D.

5. *An effect near Merak, on western Java, of the Krakatoa Eruption.* (From a paper by the Rev. Philip Neale, late British Chaplain at Batavia, in Leisure Hour.)—One of the most remarkable facts concerning the inundation remains to be told. As we walked or scrambled along, we were much surprised to find great masses of white coral lying at the side of our path in every direction. Some of these were of immense size, and had been cast up more than two or three miles from the seashore. It was evident, as they were of coral formation, that these immense blocks of solid rock had been torn up from their ocean bed in the midst of the Sunda Straits, borne inland by the gigantic wave, and finally left on the land several miles from the shore. Any one who had not seen the sight would scarcely credit the story. The feat seems almost an impossible one. How these great masses could have been carried so far into the interior is a mystery, and bears out what I have said in previous papers as to the height of this terrible wave. Many of these rocks were from twenty to thirty tons in weight, and some of the largest must have been nearly double. Lloyd's agent, who was with me, agreed in thinking that we could not be mistaken if we put down the largest block of coral rock that we passed, as weighing not less than fifty tons.

6. *Geological and Natural History Survey of Minnesota for* 1884. N. H. Winchell, State Geologist. 196 pp. 8vo.—Prof. Winchell describes in this report and gives figures of the Primordial fossils from the red quartzyte of the Pipestone or Catlinite region of Missouri, noticed on page 316 of this volume. The species described are named *Lingula calumet*, the shells of which are distributed in great numbers through portions of the rock, and *Paradoxides Barberi*. The specimen of the latter has

a length of five inches, and may be three-fourths of the whole animal. It is distorted and somewhat obscure in its markings, but appears to be a true fossil. The pipestone beds have been regarded as Huronian. They now are placed with the earlier Primordial. Prof. Winchell observes that, in several deep wells that have been drilled in central and southeastern Minnesota, a great thickness of red and green shales have been reached which may be of the same formation. He adds that red gneisses, felsytes and porphyritic felsytes in Wisconsin *overlie* the red quartzytes and are therefore brought within the Primordial zone.

The report contains also a paper by Prof. N. H. Winchell on the crystalline rocks of the Northwest, the same paper that he presented to the Philadelphia meeting of the American Association. The author becomes quite earnest in his defense of Emmons's Taconic System. He says, after arguing in its favor, that "there may be reasons why the current literature of American geology is almost silent respecting the great work of Emmons, and why the Taconic is not known among the recognized geological formations." And, in view of the future triumph of the system, it is added, "No amount of error, though heaped to the sky and supported by the highest authority can long subsist." The writer of this notice, though apparently among those aimed at in these remarks, does not feel hit by them; for he has for fifteen years endeavored by hard work in the field and various published papers to put the Taconic system into current geological discussion, and give it its right place in the geological series; and he has still more to say on the subject from more field work. Should the Taconic system, in the process, lose its identity, the time will then have come for "characterizing in deserved terms the attempt to bury the Taconic in the Quebec coffin;"* and we shall hope to have from Prof. N. H. Winchell the *obit* discourse.

Among the other contents of the Report are geological notes on portions of Minnesota by Mr. Warren Upham; on the Foraminifera and other organisms of the bowlder clay, by A. Woodward and B. W. Thomas (with a plate), and by Dr. George M. Dawson; Notes on Blue Earth County, by Prof. A. F. Bechdolt, in which an interglacial peat bed is described. J. D. D.

7. *Underground Temperatures.*—The Proceedings of the Royal Society for Feb. 12, 1885, contain an abstract of a paper on underground temperatures by Professor J. Prestwich. The author reviews the published facts, and the conditions in the several cases, in order to eliminate the more doubtful ones and reach the probable normal rate of decrease in temperature or thermic gradient. The various determinations give a range in the rate from

* In this expression, Professor Winchell alludes to the fact that Sir William Logan referred the Taconic series (after a summer's study of the region in Massachusetts, and the determination of Vermont fossils by Mr. Billings) to the Quebec Group, regarded as the middle division of the Lower Silurian. But why the work of this honest and able geologist, which *deserves* only praise, should call out rebuke from any geologist and from one who has never studied the region is to us inexplicable.

less than 30 to more than 120 feet per degree; and 30 meters for 1° C. (=54·7 feet for 1° F.) is the commonly adopted rate in Europe, while in England 50 feet is adopted by some and 60 or more by others. He considers the conditions in (1) coal mines, (2) other mines, and (3) artesian wells and bore-holes; and the action in modifying temperature taking place in mines: through (1) ventilation, (2) underground flows of water, (3) chemical reactions, and (4) the working operations; and, in artesian wells, from (1) pressure of water on the thermometers, and (2) convection currents in the column of water.

In the ventilation in coal pits the amount of air passing through varies from 5000 to 150,000 cubic feet per minute, and has a large cooling effect. It is generally greatest in the deepest mines. The escape of gas from a blow-hole is also cooling, usually lowering the temperature 2° or 3°; and in one case the temperature of 74° F. existed in the coal at a depth of 1588 feet, and 62° F. in a hole with a blower of gas at a depth of 1588 feet. The discharge of water causes a loss of heat. On the other hand, a crushing of the coal raises the temperature. There is also variation dependent on the form of the surface above, it rising under hills and falling under valleys. For correct determinations from coal mines, therefore, the height of the pit above the sea-level should be known; the exact mean temperature of the place; the depth, at each station, beneath the surface; the temperature of the air in circulation; the length of exposure of face; whether there is discharge of gas or not; the dip of the strata, and the quantity of water discharged.

Eliminating the more doubtful observations, the seven best—at Boldon, North Seaton, South Hetton, Rosebridge, Wakefield, Liège and Mons,—give a mean gradient of 49½ feet for 1° F. The bore-holes at Blythswood, South Balgray and Creuzot, give a mean of 50·8 feet.

In other mines, the loss of heat by ventilation is much less than in coal mines and that from pumped water far more. In the Gwennap district, where 550 acres were combined for drainage purposes, above 20,000,000 gallons have been discharged in twenty-four hours from a depth of 1200 feet; the water issues at temperatures from 60° to 68° F., or more than 12° above the mean of the climate, showing a large abstraction of heat from the rocks through which the waters percolate. Again, surface waters may enter and lower the temperature. The underground currents sometimes raise and sometimes lower the temperature of the rocks. Mr. Were Fox, in his many careful observations on underground temperatures gave preference to the rocks, and Mr. Henwood, an equally experienced observer, considered the springs as giving surer results. The ten best of Mr. Henwood's observations, at depths from 800 to 2000 feet, give a mean of 42·4 feet per 1° F.; and the observations in eight mines, 1100 to 2100 feet deep, by Mr. Fox, give 43·6 feet per 1° F. The observations in European mines Professor Prestwich regards as too uncertain for use.

From artesian wells and borings, when the connection waters are shut off by tubing, and when the pressure of the waters on the thermometer was guarded against, as those made at Kentish Town, Richmond, Sperenberg, Pregny and Ostend, give 51·9 feet per 1° F. In these wells the waters do not overflow. In others which do overflow, and which should therefore give the best results, as at Grenelle, Tours, Rochefort, Mondorff, Münden and others, the mean afforded is 50·2 feet per 1° F. In the Sahara Desert, the mean from 11 overflowing wells at depths of 200 to 400 feet gave 36 feet per 1° F. The author also considers the variations resulting from difference of conductivity in rocks, but makes no application of the subject.

The mean thermic gradient deduced from all the observations is 48 feet per 1° F.; but this is considered only an approximation. The question of change of rate downward also is considered but the facts reviewed gave as regards this point no satisfactory result. Professor Prestwich inquires in closing whether a gradient of 45 feet per degree may not be nearer the true normal than 48 feet.

8. *Notes on the Stratigraphy of California*, by G. F. Becker. U. S. Geol. Survey, No. 19. Washington, 1885.—In this paper, Mr. Becker treats of the metamorphic rocks of the Coast Ranges and their age; their identity with the Mariposa and Knoxville beds, but non-conformity with the Chico beds; on the relations of the Coast Ranges and the Sierra Nevada; and also on the California Paleozoic rocks, and other points in California Geology.

The age of the metamorphic rocks of the Coast Ranges is shown to be near the limits of the Jurassic and Cretaceous. They contain species of *Aucella* and other fossils near Knoxville, identified by Dr. C. A. White, and the beds are hence named the Knoxville group. Fossils occur also on Sulphur Creek in Colusa Co., and at Mount Diablo, and according to White, near the New Almaden Mine. The beds consist in part of serpentine which is one of the alteration products, as described by Whitney and others. The non-conformity with the Chico beds being established, the period of Coast Range metamorphism must have been "before the first of the Wallala beds were deposited and still longer before the opening of the Chico period"—or "neither long before nor long after the Neocomian."

The Mariposa region is one of three along the western side of the Sierra Nevada which affords fossils; it is a narrow strip of country lying along the foothills from Mariposa to Nevada, which is often known as the gold-belt proper—and its fossils, *Aucella* (*A. Piochii*), *Belemnites*, etc., are regarded as showing identity with the "Knoxville group." The rocks resemble those of the latter group in kinds and in the prevalent silicification and serpentinization. Dr. Becker observes that neither Dr. White nor himself could find any reason for maintaining that the fossiliferous rocks were not of the auriferous series; or for dissenting from Prof. Whitney's opinion that they form an integral portion of the modern

Sierra Nevada Range. From the facts it follows that the Sierra and Coast Ranges experienced upheaval long before the era of the Chico group; and that the same disturbance which determined the existence of the Coast Ranges added the gold belt proper to the Sierra Nevada; and that probably "a portion at least of the Cascade Range was elevated and metamorphosed at the same time. Consequently, before the Chico era there was a sinking," admitting the ocean over a great part of the Coast Ranges and over considerable areas at the base of the Sierra for the later depositions. During the Pliocene very little of either range was below water.

The following paragraph is from pages 22, 23 of the paper.

"I think it may be asserted, as a result of all the geological work done from the Rocky Mountains to the Pacific, that there has been, throughout geological time, a definite tendency in the structural development of this area. The geologist of the fortieth parallel exploration showed that a fault began upon the west flank of the Wahsatch in the Archæan, the same fault which Mr. Gilbert has traced as still in progress. The last-named geologist has also detected a similar fracture on the east side of the lower portion of the Sierra. The eastern portion of the Great Basin was lifted above the surface of the ocean after the close of the Carboniferous, the western portion of the same area followed before the Cretaceous, and at one or both of these epochs the country was laterally compressed, an action no doubt closely connected with the progress of the great faults. About the time of the Neocomian, California experienced an east and west compression, and again, following the Miocene, was an uplift throwing the horizontal strata of the coast into north and south folds. From the Wahsatch to the Pacific Coast there thus appears to have been a recurrent, if not a constant tendency to lateral compression, in substantially one and the same direction. Now Dr. White points out that an extraordinary difference has existed between the marine fauna of the Pacific Coast and that of the waters east of the Sierra from a time prior to the Cretaceous onward, and hence that a land barrier must throughout have occupied substantially the position of the Sierra Nevada, which must therefore have experienced repeated upheavals to compensate for constant erosion. There are also said to be some paleontological grounds for supposing at least a partial separation of these areas during the Carboniferous. This supposition is in entire accord not only with the structural analogies of the region but with the detailed observations of Mr. Clarence King* and his colleagues, who were led to infer the existence of a continental area during the Paleozoic, west of long. 117°30′, lat. 40°. Such a range as the Sierra, though partaking in the general compression and movement of the whole country, must offer a tremendous resistance; and, at any one of the active periods during which the physical conditions permitted contortion of strata along the western flank of the

*Systematic Geology, p. 534.

Sierra, these must have been driven against the barrier until they could yield no more. Thus if a pile of cloths were compressed from their edges (as in Hall's famous experiment) with enormous energy, they would be forced into plications so sharp that the dip at any point would be nearly vertical. It seems to follow that at different upheavals, some of them perhaps as yet untraced, strata to the west of the great Sierra may have been driven into the nearly vertical position of the gold slates and their original stratigraphical relations completely obscured. I do not consider it certain, therefore, or even probable that the Carboniferous slates near Pence's Ranch first assumed their present position subsequently to the Knoxville period. It may be that they have stood nearly as now ever since the Carboniferous of Utah was raised above water, while the slates of Horsetown, of the age of which nothing is known, so far as I can see, may possibly owe their vertical dip to still earlier convulsions."

9. *New American Limuloid species from the Carboniferous.*—Prof. A. S. PACKARD, in a note in the American Naturalist of March, 1885, mentions the discovery at Mazon Creek, Morris, Illinois, of a new species of *Belinurus*, and one of *Cyclus*, genera hitherto unobserved on this continent; and from the Carboniferous beds of Pennsylvania, a new species of *Euproöps*. Moreover the Cyclus, in its four or five pairs of limbs, "apparently of the same nature as those of the larval Limuli," shows that it is really a tail-less Limuloid. The species described are named *Belinurus Lacoei*, *Euproops longispina*, *Cyclus Americana* and *Dipeltis diplodiscus;* the last is Cyclus-like.

10. *Embryology of Limulus.*—Prof. PACKARD closes a note on this subject (Proc. Philad. Amer. Phil. Soc., Jan., 1885) with the following conclusions. The fact that the embryo of Limulus has at first no abdominal appendages, and only cephalic, shows divergence from the Tracheata (Arachnida, etc.) and allies it to the Crustacea. The absence of a serous membrane, of an amnion, of procephalic lobes, of protozonites (which occur in the early embryo of the scorpion and spider) show further divergence from the Tracheata. The embryology is scarcely more like Tracheata than the Crustacea; it is a primitive type more related to the branchiate arthropods than the tracheate and "should be regarded as a generalized or composite form, which with its fossil allies, the Eurypterida and Trilobita, constitute a distinct class.

11. *Town Geology: the Lesson of the Philadelphia Rocks;* by ANGELO HEILPRIN. 134 pp. 12mo, with 7 plates, and several wood-cut illustrations.—Mr. Heilprin's work is a popular illustration of some of the principles of geology by means of facts from the vicinity of Philadelphia. The figures are good, and the explanations of the subject simple and clear. The work will be found an easy introduction to the science for the young geologist. Two of the plates contain representations of Mesozoic fossils. The last of the chapters is on the Drift deposits and the era of ice, under the title of "Philadelphia Brick and Cobble Stone; a vision of Arctic Climates."

12. *Einführung in die Gesteinslehre: Ein Leitfaden für den akademischen Unterricht und zum Selbststudium von* A. VON LASAULX. 215 pp. 8vo. Breslau, (Edward Trewendt).—This little work, like another by Hussak, recently published, is especially adapted for the instruction of those who are commencing their petrographical studies. The author assumes that they have made themselves familiar with the now fully developed methods of modern petrography, mechanical, microscopic, microchemical, and goes on to describe the kinds of structure in rocks, the most important rock-forming minerals, and the classification and description of the different kinds of rocks. The author's idea of leading students to go direct to original papers for information is a good one, and with this end in view the literature of the subject is given very fully in an appendix.

13. *Pyrargyrite and Proustite.*—Dr. ERNST RETHWISCH has published, as an inaugural dissertation at the University of Göttingen, an admirably thorough discussion of the crystallographic and chemical characters of the two ruby silver ores. Such a review, especially on the crystallographic side, has long been a desideratum in mineralogical literature. The complexity of the subject may be gathered from the fact that the total number of planes identified in the two species amounts to one hundred and eight.

14. *The Marble Border of Western New England: its geology and marble development in the present century.* (Middlebury Historical Society, vol. i, part II, Middlebury, Vt., 1885).—This pamphlet contains a short paper on the geological features of the Marble belt, by Professor Ezra Brainerd, and another on the Marble Fields and Marble Industry, by Professor H. M. Seely of Middlebury, Vermont. The marble belt is for the most part the belt of the Stockbridge limestone, the great limestone of Emmons's "Taconic System." The subject is treated from an economical and historical point of view, as indicated in the title.

15. *Die Meteoriten-Sammlung des k. k. mineralogischen Hof-Kabinetes in Wien am* 1. *Mai* 1885, *von* Dr. ARISTIDES BREZINA. From the Jahrb. der k. k. geol. Reichsanstalt, 1885, pp. 151–276; with four plates.—The collection of meteorites of the Vienna Museum has long been recognized as ranking among the most important in the world. Of late years the increase has been very rapid and the present catalogue includes 358 numbers. Dr. Brezina, however, has done much more than merely give a history of the collection and a list of localities with dates, weights and so on. He discusses also at some length the origin of the peculiar structure of meteoric stones, and the systems of classification proposed. The work is therefore an important contribution to a most interesting subject.

16. *Botany of the Challenger Expedition.* Vol. I, 1885.—This bulky and well-illustrated quarto volume is devoted to the deeply interesting subject of Insular Floras, namely, of the Bermudas, of the Southern Atlantic Islands, with St. Helena, etc., of Juan

Fernandez, the Southeastern Moluccas, the Admiralty Islands, etc. And the work has been done, with admirable promptness, by Wm. B. Hemsley. To the proper systematic part, he has prefixed a general discussion of the present state of our knowledge of the principal insular floras, adding a copious bibliography; and finished with an appendix, on the dispersion of plants by ocean currents and birds. So here is much matter for consideration. We can at this moment only announce the reception of this volume and indicate the general character of its contents. A. G.

17. *Methods of Research in Microscopical Anatomy and Embryology;* by CHARLES OTIS WHITMAN, M.A., Ph.D. Boston: S. E. Cassino & Co. 1885. 8vo, pp. viii, 255.—To those who have used Dr. Whitman's notes under the head of Microscopy in the American Naturalist for several years past, this work, to a large extent based on them, will certainly be welcome. The book well accomplishes its purpose of supplying the need created by the recent rapid development of the methods of research in microscopical anatomy and embryology, for it judiciously brings together all the more important new processes used in these departments. The author says that no effort has been made to give the treatise an encyclopædic character, and perhaps for this very reason, the work appears to be much more satisfactory than Mr. A. B. Lee's Microtomist's Vade-Mecum (Philadelphia, P. Blakiston, Son & Co., 1885), which covers much of the same ground. S. I. S.

III. ASTRONOMY.

1. *The Star System* 40, o^3 *Eridani.*—Professor A. HALL has published, in the *Astronomische Nachrichten*, No. 2682, the results of thirty sets of measurements, made with the 26-inch refractor to determine the parallax of the principal star of this remarkable system. This star is of the fifth magnitude, having the very large proper motion of $4''$ a year. At a distance of $81''$ from it is a binary whose distance is now about $3''$ and whose components are of the 9th and 11th magnitudes, and this binary has the same extraordinary proper motion as the principal star, the three stars being presumably physically related.

Professor Hall made observations in March and September, 1884, and March, 1885, comparing with a 10th mag. star $32^s{\cdot}5$ following and a little south of 40 Eridani. His result is

$$\pi = 0''{\cdot}223 \pm {\cdot}0208.$$

Although the observations were made with difficulty, owing to the small field of view of the telescope, yet Prof. Hall expresses much confidence in his result.

Since the commencement of Prof. Hall's observations in March, 1884, Dr. Gill has published the measurements made by himself and Dr. Elkin upon several Southern stars, and among these is a determination by Dr. Gill of the parallax of 40 o^3 Eridani, viz:

$$\pi = 0''{\cdot}167 \pm 0''{\cdot}018.$$

These two results agree in showing that this system is more distant than its large proper motion would lead us to expect.

Dr. Gill compared the star with two stars of the 6th and 6·7th magnitudes, over a degree distant in opposite directions, thus eliminating the temperature corrections. The star passed much nearer the zenith of Cape Town than of Washington.

The observations upon the close binary indicate a period of revolution between 125 and 140 years, of which 102 have elapsed since Herschel's first observation. If we take the mean of the two determinations of parallax, the mean distance of the close binary is about 25 radii of the earth's orbit, and the sum of the masses of these components is not largely different from the sun's mass.

The distance of the principal star from the binary, measured perpendicularly to the line of sight, is a little over 400 radii of the earth's orbit. Distinct evidence of rotation of the binary about the principal star is yet wanting.

Measured in units of annual velocity of light, Prof. Hall's parallax implies a distance from us of about 15, while Dr. Gill's parallax gives a distance of about 20.

2. *Report No. 8 of the Cincinnati Observatory. Observations of the Comets of* 1883, by H. C. Wilson, Astronomer pro tem.; published under the direction of J. G. Porter, A.M., Astronomer. Cincinnati, 1885.—The Report No. 7 gave the results of the observations at the observatory on the comets of 1881 and 1882. No. 8 contains the results from comets I and II of 1883 (the Brooks-Swift and Pons-Brooks comets), made by Mr. H. C. Wilson, assistant astronomer during the time that he was in temporary charge of the observatory. The report is illustrated by 13 fine plates, 11 of which are devoted to views of the comet at different times during its passage.

IV. Miscellaneous Scientific Intelligence.

1. *The Washington Co., Penn. Meteorite;* by G. F. Kunz.—At 4 o'clock on Saturday evening, September 26th, 1885, under a remarkably clear sky, a meteor passed over several townships of Washington County, in southwestern Pennsylvania. Its general direction was southeast over Hanover township, Burgettstown in Smith township, Jefferson township, Cross Creek village in Cross Creek township, the village of Hickory in Mt. Pleasant township, Canonsburg in Chartiers township, and Cecil township. The falling body was also distinctly seen and heard in many towns in southwestern Alleghany County, as Bridgeville, Mansfield, Middletown and McKeesport. The great noise and disturbance which it created were attributed to various causes, usually to the explosion of some boiler in the neighborhood or blasting in the quarries. The meteorite undoubtedly exploded and fell somewhere in this section.

Mr. John Connor of Canonsburg writes that the meteor passed over his house, accompanied by a loud roar like a peal of thunder.

He himself was in the barn at the time, and on account of the brightness of the day, thought that a boiler had exploded on his farm at a spot where a company were prospecting for oil. The only person on the farm who witnessed the sight was a lad of 17, named Richardson, who was visiting there and happened to be out in the fields. He reports that he heard a queer hissing noise quickly followed by a roar, as of thunder. Young Richardson, probably deceived by the excessive glare of the meteor, thought it fell on the Connor farm, but a thorough search failed to discover any fragments there. Professor Tingley of Alleghany College, Meadville, Penn., kindly volunteered his assistance and devoted several days to inquiry, visiting the Burgettstown County fair then in progress, and searching far and wide for a trace of any meteoric fragments, but he was unable to hear any rumors of the finding of any. It is probable that the mass fell in some unfrequented woods, where it may not be discovered for some time, as meteorites appear to the startled observer to be much nearer than they really are. Numerous exaggerated and sensational accounts, purporting to give accurate details of the fall of enormous meteoric masses, have appeared in the newspapers, yet in all cases these have proved to be myths, unsubstantiated by the finding of any fragments as yet.—*Read at the New York Academy of Sciences*, Oct. 12th.

2. *British Association at Aberdeen.* — The meeting of the British Association opened at Aberdeen on the 12th of September. From *Nature* of Sept. 10th, we learn that up to the preceding Saturday, the local committee had disposed of tickets to the value of 1,000*l.* to "local people alone; and that 2,500 people were expected to take out tickets for the meeting. The actual number attending the meeting was 2,203. The grants of money made for research amounted to 1,195*l.*"

The President of the meeting, Sir Lyon Playfair, discussed, in his inaugural address, the relations of Science to the State and the claims of Science from the State, with special reference to its place in education. Germany, as is usual, was appealed to for incentive; and the fact was stated in this connection that:

"Strassburg has had her university and its library rebuilt at a cost of 711,000*l.*, and receives an annual subscription of 43,000*l.* In the rebuilding of the university eight laboratories have been provided so as to equip it fully with the modern requirements for teaching and research." "The cost of these laboratories has been as follows: Chemical Institute, 35,000*l.*; Physical, 28,000*l.*; Botanical, 26,000*l.*; Physiological, 13,900*l.*; Physiological Chemistry, 16,000*l.*; Observatory, 25,000*l.*; Anatomy, 42,000*l.*; Clinical Surgery, 26,000*l.*"

The reports of the meeting show that it was fully as successful as any that have preceded it. Professor G. Chrystal's address before the Physical Section, like Sir Lyon Playfair's, was on the Diffusion of Scientific knowledge; and Professor Armstrong's, before the Chemical, inclined in the same direction, the first half

treating of the importance of encouraging chemical research and education, the latter half, of chemical action. An abstract of Professor Judd's address before the Geological Section is given on page 392. Francis Galton, F.R.S., before the section of Anthropology, gave a "lecture," as he termed it, on "types" and their "inheritance"—"gathered from family records entrusted to him by persons living in all parts of the country." Professor W. C. McIntosh's address before the Biological Section, reviewed the subject of the phosphorescence of marine animals.

The work of the association is reported quite fully in *Nature*, commencing with the number for September 10th (No. 828). The several addresses of the Vice-Presidents are given in full. Birmingham is to be the next place of meeting for 1886, and Sir William Dawson the President of the meeting.

3. *Louis Agassiz, his Life and Character;* edited by ELIZABETH CAREY AGASSIZ. 2 vols., 794 pp. 12mo. Boston, 1885. Houghton, Mifflin & Co.).—The very general admiration for Professor Agassiz will be sustained and enhanced by the story of his life, prepared with excellent taste and judgment by Mrs. Agassiz. It sets forth by a skillful interweaving of letters and narratives, in language as vivid and simple as Agassiz's own style, the early surroundings of the young naturalist, his development under an ardent devotion to Nature as his chief teacher, and his accomplished work by which he became a lasting power in the world. The work is hence of interest to the philosopher for its illustration of the type of man, under one of its phases, to which science owes its recent progress. At the same time the biologist, paleontologist, and geologist, here learn of the successive stages in the establishment of the new views, which were the outcome of his study of nature; for example, how in 1837, the idea of a northern ice-period was struck out in Agassiz's intercourse with the Alps and Juras; the Alps giving the actual glacial phenomena to his mind, the Juras as well as Alps affording the same kind of glacial records on rocks and heights miles outside of and thousands of feet above modern ice-limits—a view which later he corroborated in the Scottish Highlands and in America.

Agassiz's part in the progress of science was so important that the volumes have great value for their contributions to the history of science. But, after all, the attractiveness of the man at his work and among men gives the pages their chief charm.

Americans have reason for holding Agassiz in high honor, in view of his devotion, almost from the day of his arrival in this country, to the interests and exaltation of American science. He sent none of his various memoirs to foreign journals or academies for publication, because, as he told the writer, he was now an American. J. D. D.

4. *Hawaian or Sandwich Island Survey.*—The survey of the Hawaian Islands has been in progress for some years, under Professor W. D. Alexander as Surveyor General. In 1881, a detailed map of Oahu was published, measuring nearly five feet by

three-and-a-half, showing well its remarkable precipices and the system in its heights and valleys. Recently a survey has been made of the small western island of the Hawaian Chain called Nihoa or Bird Island. The island is 5200 feet in extreme length and 2000 in mean width. It is the remains of the upper unsubmerged portion of a volcanic mountain. The highest point is near the northwest angle and is 903 feet above the sea level. The northeast is but little lower, 869 feet. The north, east and west sides are precipitous, and from the top of the bluffs, there are gradual inward slopes, like the slopes of a crater, leading down to a large, partly enclosed bay, which occupies nearly the whole south side. Great numbers of dikes intersect the high precipices on the northwest side which were found to traverse the whole island. The survey indicates that the island was once the site of a great volcano, and the dikes show the courses of fissures through which the lavas flowed at various eruptions.

OBITUARY.

JAMES MACFARLANE, of Towanda, Pa., died suddenly on the eleventh of October. He was born at Gettysburg on the second of September, 1819, was graduated at Pennsylvania College, of the same place, in 1837, studied law at Carlisle, and was admitted to the bar in 1845. He made himself well acquainted geologically with the coal-measures and coal regions of Pennsylvania, and published a work of great value on the Coal Fields of America. His "Geologists' Traveling Hand-book," in which the formations along all railroad routes in the country, as far as known, are given, proved to be a great convenience to travelers, and of much value to the science; and during the two or three years past he has been engaged in its revision for a new edition—and a printers' proof arrived on the morning of his decease. His occasional papers have reference mostly to the Coal-measures.

THOMAS BLAND was born at Newark, Nottinghamshire, England, Oct. 4, 1809. His father, Dr. Thomas Bland, was a physician. His mother was a Shepard, and a niece of Richard Shepard, who was a conchologist, from whom she acquired a love of natural history which led her to make collections of plants, minerals and shells, and this love of nature was inherited by her son Thomas. He was educated at Charter House School in London, where he was a classmate of Thackeray. He subsequently studied law and entered upon its practice in London. In May, 1836, he became a Fellow of the Royal Geological Society of London. In 1842 he removed to Barbadoes and thence to Jamaica, where he resided until about 1850, collecting largely in various departments of natural history, especially in chonchology. While at Jamaica he made the acquaintance of Prof. C. B. Adams, then of Middlebury College, Vermont. A close friendship ensued which ended only with the untimely death of the latter in 1853. In 1850 Mr. Bland returned to England, and after a stay of a few months, accepted the appointment of superintendent of a gold mine at

Marmato, New Granada. In 1852 he removed to New York, where the remainder of his life was spent in various agencies connected with mining and other enterprises. Of late years he had suffered much from impaired health, becoming for the last few months incapacitated for mental labor, and on the 20th August, 1885, he passed peacefully away.

Though Mr. Bland was always interested in general science, he seems to have received the special direction toward the study of terrestrial mollusks from his intimate friendship in Jamaica with Prof. Adams. He devoted himself to the wonderfully rich fauna of the West India islands, and continuing the labors which Prof. Adams had begun, he soon became a leading authority on that branch. His general knowledge of science led him to devote particular attention to the subject of geographical distribution, so philosophically treated in his published papers. When in South America, he collected largely and corresponded on the subject with all the prominent European conchologists. Again, on removing to New York, he became, through Prof. Adams, acquainted with the American conchologists, and formed a strong friendship especially with Mr. Wheatley and Mr. Redfield. Through the latter he became a member of the New York Lyceum of Natural History, and was for many years a most useful member of its publication committee. He was also a member of the Natural History Societies of Boston, Philadelphia, and other American cities, and the intimate personal friend and correspondent of all the American conchologists.

In 1855 he became acquainted with Mr. W. G. Binney, who was just commencing the continuation of his father's work on the Terrestrial Mollusks of North America. An intimate friendship was established which was only broken by the death of Mr. Bland. The association of these two in the study of our land shells resulted in a series of publications which has thoroughly elucidated the subject. If these publications have any excellence, it is owing to the happy combination of untiring zeal and inherited love of the subject, with all the traditions of the collections and collectors on one side, and on the other the absence of prejudice, the extended experience, the general scientific training and especially the philosophic mind of Mr. Bland.

A detailed catalogue of Mr. Bland's scientific writings, seventy-two in number, has been prepared and published by Mr. A. F. Gray.

Finally, it must be said that Mr. Bland was a genial acquaintance and a most self-sacrificing friend, ever ready with assistance, advice, encouragement or consolation, as these qualities might be required. W. G. B.

Edward Henri von Baumhauer, Editor of the Archives Néerlandaises des Sciences exactes et naturelles published by the Société Hollandaise des Sciences at Harlem, and secretary of the Society, died on the 18th of January last, in his 66th year. The success and European character of the Archives is largely due to his enterprise and science.